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Improving Purchasing by Inventory Management

Inventory Management in Spare Part Business

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The objective of this Master's thesis was to improve purchasing by inventory management in spare part business. In inventory-managed purchasing, set inventory control parameters control purchases. The parameters are set to control stock levels. The primary function of the business is to meet customers' needs as quickly as possible. Availability can be guaranteed, for example, by storing products but it is not commercially viable to stock all of them. In this case, inventory management and inventory optimization become important elements for achieving the primary function. Holding stock improves availability and allows immediate response to the needs. This way, stock improves customer satisfaction and promotes business continuity.

The scope of the thesis was limited to one product group. A product-specific annual demand, the nature of the demand and the way of acquisition affect which stock control method is chosen. The implementation of suitable methods was also limited so that the methods had to be feasible in the Target Company's ERP system. In this case, the ERP system defined the methods and tools. The thesis was started with a present state analysis, after which a theoretical framework was built to support the inventory-managed purchasing. Then optimization was done based on the Order Point -method. The inventory control parameters obtained from the optimization were to be implemented in the next stage of the work. Unfortunately, during the work, the way of acquisition of the product group was changed, and implementing the results of the optimization became unnecessary. Because of this, simulation was performed for obtaining results. Due to the change in the acquisition, a plan for inventory-managed purchasing was made and implemented adapting the new way of acquisition.

The results of the thesis were reduction of operational purchasing work and its facilitating, reduction of products in stock and implemented inventory control parameters, and a wider utilization of the ERP system. In conclusion, this development task turned out to be just a kick-off in the improvement of the inventory management and, therefore, several new development ideas emerged.

Keywords	Inventory management, inventory-managed purchasing, stock control parameters, spare part business

Tekijä Otsikko Sivumäärä Aika	Kaisa Peltoniemi Ostotoiminnan parantaminen varastonhallinnan avulla Varastonhallinta varaosaliiketoiminnassa 49 sivua + 3 liitettä 10.8.2018
Tutkinto	Tradenomi (ylempi AMK)
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Tämän kehitystehtävän tarkoitus oli parantaa varasto-ohjautuvaa ostamista varaosaliiketoiminnassa. Varasto-ohjautuvassa ostamisessa asetettujen ohjausarvojen avulla ohjataan ostamista ja hallitaan varastoitavien tuotteiden kappalemääriä. Varaosatoiminnan päätehtävä on tarjota tarvittavat varaosat asiakkaille mahdollisimman tehokkaasti. Tehokkuudella tarkoitetaan tuotteiden välitöntä saatavuutta. Saatavuutta mahdollistetaan muun muassa varastoimalla tuotteita. Kaikkien tuotteiden varastointia ei voida tehdä, koska se ei ole liiketoiminnallisesti kannattavaa. Tällöin varastonhallinta ja sen optimointi ovat tärkeitä elementtejä toiminnan tavoitteiden saavuttamiseksi. Varastoinnin avulla parannetaan toimitusvarmuutta, jonka johdosta asiakastarpeet tyydytetään nopeasti. Näin varastoiminen parantaa asiakastyytyväisyyttä ja edesauttaa liiketoiminnan jatkuvuutta.

Kehitystehtävän tavoite oli optimoida varaosavarasto. Tehtävä rajattiin koskemaan yhtä tuoteryhmää. Tuotteiden menekki, menekin luonne ja hankintatapa vaikuttavat varastonhallintaan ja varastonhallinnassa käytettäviin työkaluihin ja menetelmiin. Varastonhallintaan soveltuvien työkalujen ja menetelmien käyttöä rajattiin myös niin, että niitä oli pystyttävä käyttämään kohdeyrityksen toiminnanohjausjärjestelmän kautta. Tällöin toiminnanohjausjärjestelmä määritteli mahdolliset menetelmät ja työkalut. Tämä tehtävä aloitettiin nykytila-analyysillä, jonka jälkeen rakennettiin teoreettinen viitekehys tukemaan varasto-ohjautuvan ostotoiminnan parantamista. Valitettavasti tehtävän aikana valitun tuoteryhmän hankintatapa muuttui, jolloin suunniteltua tilauspiste-menetelmän implementointia ei voitu tehdä. Tämän vuoksi tehtiin simulointi kehitystehtävän tulosten saamiseksi. Koska hankintatapa muuttui, tehtiin suunnitelma varasto-ohjautuvan ostamisen toteuttamiseksi uutta hankintatapaa mukaillen. Tehty suunnitelma myös implementoitiin.

Kehitystehtävän tuloksia olivat operatiivisen ostotyön vähentyminen ja helpottuminen, varastoitavan tuotemäärän pienentyminen sekä implementoidut varastonhallintaa ohjaavat varastonohjausarvot. Kehitystehtävä osoittautui pintaraapaisuksi varastonhallinnan parantamisessa sekä varaston kehittämisessä, ja siksi jatkokehitysideoita syntyi useampia.

Avainsanat	Varastonhallinta, varasto-ohjautuva ostaminen, varastonohjausarvot, varaosaliiketoiminta

Contents

1 Introduction

"Supply chain management (SCM) is the management of a network of interconnected businesses involved in the ultimate provision of product and service packages required by end customer. SCM spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin of consumption" (Samson 2011, ix).

This Master's thesis was performed to achieve a more effective supply chain in spare parts business. The aims of the thesis were to make more use of existing enterprise resource planning system (ERP) in inventory management and to decrease workload due to operative purchasing when appropriate. ERP tools were especially needed for inventory management purposes; demand forecasting, inventory availability planning and automation of purchasing. This Master's thesis deals with inventory-managed purchasing from a viewpoint of a separately chosen, specified product group.

In the Target Company's spare parts business was increasing need to develop purchasing activities for the growing business. The activities were handled by a purchaser, whose full-time working hours were not enough to handle all the work. The purchaser is responsible for operational purchasing; ordering, order monitoring and invoice handling, supplier relations; cooperation and development of the relation, product data updates; possible new suppliers, bidding activities and sales product pricing, and availability of sales products; inventory management. In the purchaser's point of view, an instant need was to analyze and rationalize existing stock and to automate operative purchasing by the ERP tools as much as possible. Using the ERP system more widely, the system could provide information for optimizing the entire inventory. By these changes, the purchaser could be capable to focus on proactive purchasing instead of reactive purchasing.

There were questions in four different sub targets that needed to be answered. Firstly, what are the potentialities of existing ERP system to provide forecasting of demand, to optimize stock levels and to define stock keeping units (SKU), to analyse inventory turnover ratios and to automate purchases? What kinds of ERP tools are existing, how to set up and use them? Secondly, there is a large number of products and no actual high-volume products in the business, how to predict the need and to plan stock availability in

an intermittent and lumpy demand where customer's need is now or sooner and the number of spare part products is huge? Thirdly, what are the products and product classes that are reasonable for the business to dedicate resources? In what kind of categories the products should be divided into? And finally, the business is measured using three key performance indicators (KPI), but purchasing functions are not measured. What are suitable indicators for purchasing and what are the benefits of measuring it in this particular business?

At the beginning of the research it became very clear that all the set sub targets cannot be solved within this research. Simply too many issues to study and solve in a short time.
Because of this, the aims and objectives were limited to following subjects:

1. **studying inventory-managed purchasing and studying methods for stock control**
2. **studying Target Company's ERP's planning tool for a successful inventory management**
3. **Implementing the learned knowledge to a separately chosen, specific product group if reasonable and clarifying the needs for future development.**

This development work was performed by an action research. The first step was to analyse the present state. After that, the appropriate theory was investigated and studied. Together with the Target Company's business management, the directions for the development as well as desired goals were found and accepted.
In the beginning of 2018 the business management decided to change the way of acquisition of the specified product group. At this point the optimization was already done and the implementation was supposed to be performed. Because of the change, the implementation could be performed only partly. The implementation was done on March 2018. There was no time to go back to the drawing board, so the simulation of 2017 was performed to get the results. The simulation was performed on April 2018. The simulation should have been performed anyway to evidence the effect of the changes that had been done, since the results of the implementation would not have been visible during this action research.
Because of the change, a plan for inventory-managed purchasing that adapts a new way of acquisition was made on April 2018. Some results could be derived from the plan and are presented in this paper.

2 Glossary

ERP, **Enterprise resource planning**	refers to a company-wide information system for managing the company's operational and support processes (Weele 2014, 256)
EOQ	economical order quantity
Inventory turnover	measures economic efficiency of inventory control of meeting demand (Baily etc. 2005, 142)
KPI, **Key performance indicator**s	are derived from a company's strategy. The course of an action and the achievement of goals are measured by set key performance indicators
MRP, **Materials requirements planning**	is a tool for purchasing and inventory planning which determines a need of materials
Q1-4, **Quarter 1-4**	quarter of a year. Q1 is January-March, Q2 is May-June, Q3 is July-September and Q4 is October-December
Spare part business	one of the Target Company's business units which is managed by the Service department
Service level	measures success in meeting demand off the self (Baily etc. 2005, 142)
SKU, Stock keeping unit	is a unit in stock
Target Company	a company for which the thesis is performed for

3 Master's Thesis for a Target Company

A company's development work is usually performed to achieve new or more effective practice, function or way of working. Development work is performed also for creating or developing products or services based on the environment the company is performing at and for the needs of the company. (Ojasalo, Moilanen & Ritalahti 2015, 11)
This Master's thesis is a development work performed for a target company and performed as an action research. The purpose of the action research is to investigate, analyze, develop, implement and summarize knowledge for the target company's needs. (Masters 2018, 4 and 11)

It is very important to understand that continuous development is a key factor for company's success. By continuous development the company is capable to respond to future demand and make plans for the future in a variable environment. Digitalization and globalization create needs for changes in companies' operations. The global knowledge is increasing all the time. It means that companies' operations are based more and more to knowledge and its management. It is crucial to find, study and understand the precise knowledge from the mass of data that serves the company's needs. At the same time the speed of changes is increasing and predicting the future becomes more complicated. Company's success depends on how capable the company is for transformation and how flexible the company's operations are for changes. The company's ability to innovate, for example customer-driven innovations, enables company success in the future. (Ojasalo etc. 2015, 12-14)

An action research is considered as one of the qualitative research methodologies. The qualitative research aims at deep understanding of a phenomenon. It is a flexible research methodology that can be proceeded and performed according to the prevailing situation. During the qualitative research, new hypotheses are created. Qualitative analysis is a cyclical process. The analysis is a continuous activity that goes on through the research. The analysis guides the research process and data collection. In a qualitative research process, analysis and data collection alternate. (Kananen 2014, 20-23)

One element of the action research is a permanent change. This way the action research gives a promise for a better future. This can also be seen as a democratic activity that begins with those that it concerns and their own power to find a solution for the issue. The action research is a continuous improvement of operations. (Kananen 2014, 11)

The action research requires scientific and social debate of the field the research is associated with. The research's performer must be an expert with a large knowledge of different research methods. This is how the action research differs from a functional thesis. In the functional thesis the performer is a student who is emerging as an expert and the scientific and social debate is not demanded. (Vilkka 2006. 76-77)

3.1 Scope of the thesis

The objects of this action research were the Target Company's spare parts stock and spare parts purchasing. The main targets in this action research were to explore suitable ways to perform

- inventory management in spare part business
- purchasing that decreases work load in operative purchasing

The purpose was to reduce the amount of operative work in purchasing by migrating from order-managed to inventory-managed purchasing. The idea was to study the opportunities of inventory-managed purchasing. These opportunities had to be suitable to be executed with the Target Company's ERP and had to follow the Target Company's goals. Therefore, the first steps were to clarify the goals for the inventory management and to explore existing inventory management opportunities from the ERP. In this action research the migration was not performed nor implemented.

The purpose was not to get rid of order-managed purchasing, but to develop purchasing function, where appropriate, to inventory-managed direction. This aims at managing the products in stock by product classes. In this action research the product classification has not been performed nor implemented, but the classification has briefly discussed because it is heavily associated with the inventory management and is related to the future development.

According to my opinion and experience, the inventory management seeks to obtain an **optimized state** of a stock. This means a stock state which is serving the Target Company's business in the best possible way. The more efficient the inventory management and the purchasing activities are, the better the **customer satisfaction** will be, and the continuity of the business is ensured. After all, it is always about customer satisfaction. The speed and punctuality of customer order deliveries are increasingly affecting the

decision of where the customers are ordering the products (Salmivuori 2010, 7). In the Target Company's spare part business, the **availability** plays a very big role, because usually the customers enquire spare parts when the actual need prevails. It means that the business must be able to respond to the need as rapidly as possible. Without **stocks and accurate management**, it cannot be done. However, this doesn't mean that the stock needs to be located in own premises or in own accountancy.

In this action research the optimization for the entire spare part stock and all its products was not possible to be performed. Therefore, **a specific product group (chapter 3.1.1) was chosen to be studied and optimized.** This action research deals the inventory-managed purchasing from a viewpoint of chosen product group.

Achievements of the action research were expected to be

- **optimized product-specific stock control parameters implemented in the ERP to control the stock levels and purchases**
- **knowledge of using ERP's Inventory part planning tool**
- **ideas for further development**

The achievements of this action research were measured with the following metrics (1-4).

1. **Customer service; late deliveries in 2017 compared to late deliveries in simulation. Delivery gets the status "late" if it's not delivered from stock.**
2. **Inventory turnover; the change between non-optimized and optimized. In inventory management, the turnover rate indicates the efficiency in rotation. The higher the rate the better the rotation. (Chapter 5.1)**
3. **Average yearly inventory value (%); the difference between non-optimized and optimized inventory values.**
4. **Work load (%); percentage difference between time spent per purchase order line in 2017 and time spent per purchase order line in optimization.**

3.1.1 Validity, Reliability and Verification

The output data for this action research was gathered from the Target Company's ERP system. The data accuracy is controlled by annual audits based on existing quality standards to which the Target Company is committed. User authorizations are limited to specific profiles according to the job description. The data in the system is unchangeable unless someone purposely changes it. In case of a change, the person behind the change can be pointed out and made change can be questioned. A manually made change always leaves a mark in the system.

The Target Company's ERP system limited the use of potential theories because the developmental change was to be feasible in the ERP system. The theories used in this action research are valid in this specific intended use. The theoretical framework was investigated and built to support the scope of this action research. It goes without saying that all the world's theories were not studied but appropriate theories were widely investigated. Used theories were derived from several sources and the found sources supported each other. The theories were chosen so that they were applicable to the development tasks and responded to its demands and research questions. The theories mentioned in this action research are commonly and well known in literature on supply chain management, inventory management, logistics, purchasing, etc.

The data used in this action research can be repeatedly gathered from the ERP system. Output data was heavily processed during the research but all the actions done are documented and archived, and can be verified. Unpredictable changes in business environment as well as strategic changes done by the business management can affect the verification and validity of this research. However, there are no remarkable changes expected in the near future. As mentioned before, the research is performed for the particular product group in this particular business environment.

4 Present State Analysis

This chapter discusses about the present state of a stock, and its functions and management. The stock belongs to the Target Company's Service department's (Service) Spare part business, and is part of the Target Company's Inventory. In order to obtain a better overall view of the present state, a stock and its functions under Project department (Project) may be briefly introduced and discussed. This chapter is written from a Service's purchaser's point of view.

4.1 Inventory

This inventory present state analysis was made based on the inventory levels on 27.10.2017 unless otherwise advised. Output data was collected from the ERP system. The ERP query was made using the criteria: all inventory parts in stock with on-hand quantity more than zero. The result was

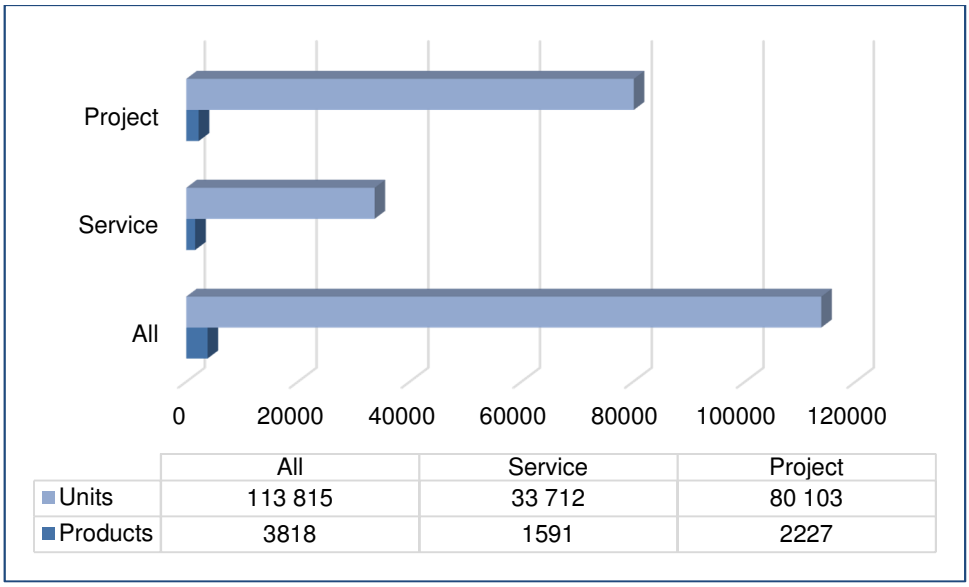
- 3 818 different products and
- 113 815 pieces of product units in the Inventory.

The Inventory contains all inventory parts with on-hand quantity more than zero, without considering the stock location. For example,

- Part A: on-hand quantity is three pieces and is stocked at supplier's premises and
- Part B: on-hand quantity is one piece and is stocked at the Inventory.

According to the above, all the 113 815 pieces of product units are not at the same location nor in the Inventory.

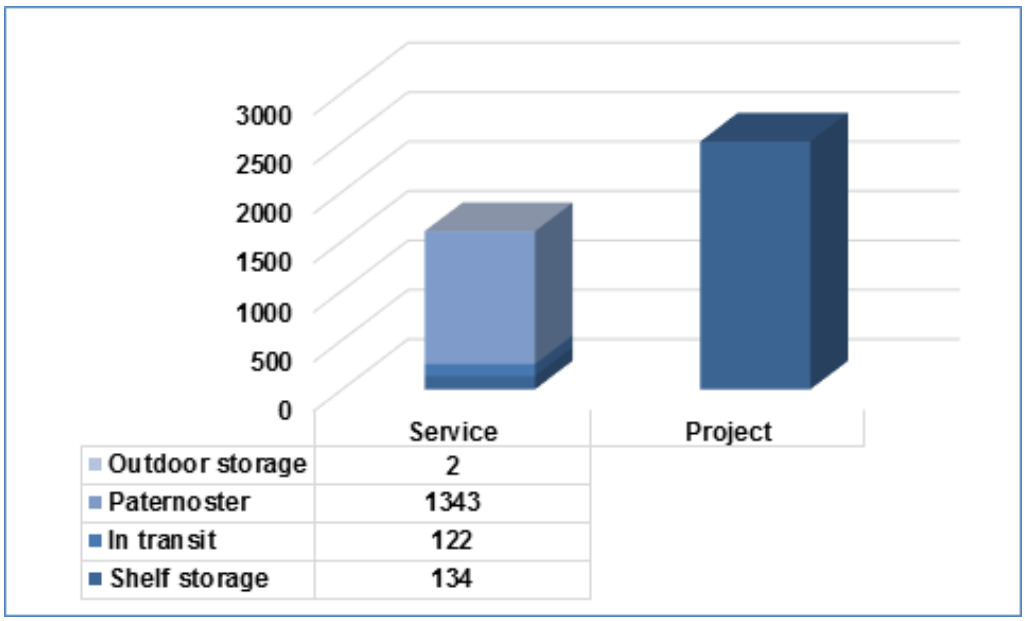
The Inventory is split in two stocks; Project and Service stock, according to the business operation as figure 1 illustrates. Inventory is split for management and cost posting reasons. However, the businesses; Project and Service, are both using stocks in daily basis. In practise, the split is visible only in the ERP system and in management level. There are also some stocks located in suppliers' premises, these stocks are under Project stock.



	All	Service	Project
Units	113 815	33 712	80 103
Products	3818	1591	2227

Figure 1. Inventory split; Service and Project, 27.10.2017

All product units that are under Service stock are located in the Inventory. There are a few different stock locations where the units are placed. In figure 2. Service's stock locations are summarized.



	Service
Outdoor storage	2
Paternoster	1343
In transit	122
Shelf storage	134

Figure 2. Service's stock locations in the Inventory on 27.10.2017

- Outdoor storage is a storage for large units that are not appropriate size for inside storing,
- Shelf storage is for units on ballets,

- Paternoster is a vertical carousel storage (Rushton etc. 2015, 293-294) where small units are stocked. The Paternoster is a primary storage, all units that are appropriate size are stock there,
- Storage called “In transit” is for units that are purchased for a customer order and received in the Inventory. Units are In transit -storage until customer order picking, before customer order delivery.

There was 1 591 pieces of different products and 33 712 pieces of product units in Service stock. Based on my calculations, 20% of products holds a bit less than 83% of total stock value and 10% of products holds 70% of total stock value.

What comes to a product classification in inventory management point of view, it does not exist.

Table 1. Percentage value in pieces by product category.

	20% of stock value	10% of stock value
Manufactured product	93 pcs	50 pcs
Commercial product	226 pcs	109 pcs

As illustrated in table 1, there are two types of products; products to be manufactured and products to be purchased. This classification is made when a product is designed and/or set up in the ERP system. In table 2 guidelines are descried for the classification.

Table 2. Guidelines for product classification.

Own design	D-product	Manufactured product
Own design	S-product	Manufactured product
Not own design	C-product	Commercial product
Not own design	M-product	Commercial product

- D-product is a single product designed by the company,
- S-product is a product assembly designed by the company,
- C-product is a product supplied by a supplier or a business partner and
- M-product is a product supplied by a supplier and is purchased in meters

Despite the fact that there are many products in Service stock, the actual stock keeping units (SKU) doesn’t exists. My opinion is that the SKU is a product in stock that storing

is carefully managed. Managing includes classification, demand forecasting, and purchase and stock planning. Service stock is filled with a gut feeling. The inventory split was done a few years ago, since the split, Service's stock never studied for smart inventory planning, monitoring nor handling.

In Service, there are no knowledge for using ERP's inventory management tools. The ERP carries certain inventory management tools, for example Inventory part planning – tool, as shown below in figure 3, but there are no practical experience or know-how of using them. There are a few ERP system administrators in the company. None of them is responsible for actively developing the usability of the ERP's inventory function.

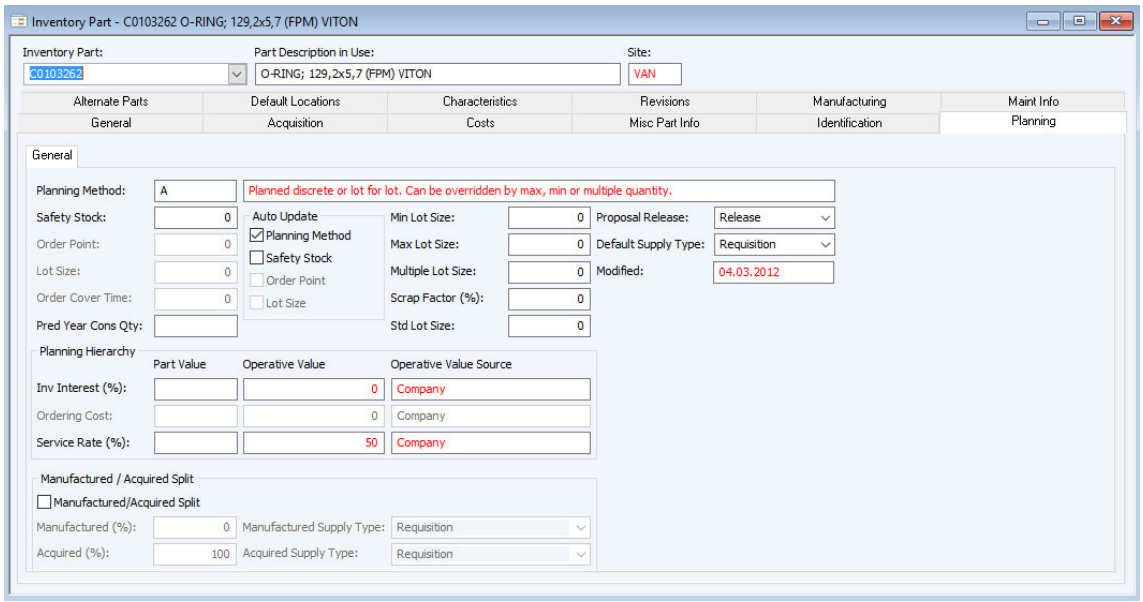


Figure 3. Inventory part planning tool

Despite the lack of the knowledge, some products are set up as MRP (material requirement planning) parts. Meaning, the ERP creates automatically a purchase requisition as soon as a product need occurs, or if safety stock level is set up in the planning tool, as soon as the safety stock level is undercut. It is worth noting that the ERP contains several different inventory planning methods for different kinds of needs. In figure 3 can be seen that A-method has been chosen. This is the only method that is in use in the Target Company. According to ERP's Material Requirements Planning -instructions, the method A, Lot for Lot, is for use with expensive parts that are not often needed, and safety stock can be used if planning is uncertain. In the Target Company, the safety stock is used for triggering the need. According to the instructions, that kind of a need should be handled

for example by the method B, Order Point Planning. (Material Requirements Planning, 39).

In case of an MRP-product, the safety stock level is set up manually as well as order quantities; minimum and maximum. There could be a possibility to calculate safety stock levels through the ERP by the set values (as expected annual consumption, service rate, inventory interest, etc.) and by using suitable method. The functionality has not been studied. There is also an ERP tool for calculating an inventory turnover for a single product. The functionality has not been studied either.

Inventory management is handled by the Target Company but operative inventory functions are outsourced to another party, i.e. service provider. In practise, inventory is managed in cooperation with the service provider. Commonly, outsourcing means that the activities outside a company's core competence are delegated to a service provider. The idea is to buy a service from a service provider of which core competence the outsourced activity is. This how the company can focus on their own core competence and business development. (Iloranta, K. & Pajunen-Muhonen, H., 2015. 169; Rushton etc. 2015, 561) A Service provider is responsible for receiving, storing and sending products. The used term for this is 3PL which means 3rd Party Logistics. (Salmivuori 2010, 22)

The Target Company's outsourced inventory functions are

- receipt and acceptance of goods,
- goods placing on stock locations,
- picking and packaging of goods,
- handing over of goods to freight forwarders,
- occasional transport booking,
- purchasing of MRP goods,
- annual inventories and
- other practical stock functions

There is one named person working for Service stock. The person is employed by the service provider. Service's logistics and purchasing are working together with the person for picking, packing and dispatching the goods on time. Service's purchaser is responsible for functional inventory operations, meaning in case of a problem, the purchaser is the first contact for problem solving.

4.2 Purchasing

This state analysis of purchasing was made exploring placed orders and received products during 2017. Output data was collected from the ERP system. The ERP-query was made using criteria: all purchase order lines placed by the Service and received at Service stock during 1.1.2017 – 27.10.2017, and all received inventory parts at Service stock during 1.1.2017-27.10.2017.

During the period mentioned above, there was 672 pieces of purchase orders placed by the Service and 163 different suppliers used for ordering. 672 orders held 1745 purchase order lines. 79 order lines in 55 orders were placed for storing purposes and the value of these stock order lines was less than 11% of all placed order lines. As mentioned before, the Service stock is filled with a gut feeling. If the purchaser has had a feeling that the product which is required now by a customer order, is quite often required, she may have ordered additional units. Nevertheless, the stock's annual value has not changed much during years, so it may be assumed that the stock contains a lot of unnecessary goods for which there is no use of any kind. Most of the orders were addressed to suppliers located in Finland, 105 were addressed directly to suppliers located abroad.

Except for a few exceptions, the Service’s purchases are performed reactively. The demand of the previous years has not been analysed nor has the forecasting of the sales been performed in any way. This is one of the reasons why the Service purchasing is not capable to perform proactively or to take advantage of inventory-managed purchasing. Of course, the purchasing could do the math by itself, but because of a lack of resources, it has not been possible. What comes to the ERP tools for analysing of demand and forecasting of sales, ERP possibilities have not been studied and no practical experience exists.

All inventory and purchasing functions are performed through the ERP. It means, for example, all products in the Inventory are visible in the ERP, if a product is transferred to a specific project or delivered to a specific customer, the transfer or the delivery is processed and visible also in the ERP, or if purchase needs to be done, the purchase order will be created and sent via ERP.

One of the purchaser's main responsibility is to perform operative purchasing. "Operational level tasks are routine purchasing tasks, such as home call orders. These decisions are made on a daily or weekly basis and are done most at expert and employee level" (Anttila, Jussila, Mikkola 2013, 16). Service's purchaser's operational level tasks are creating purchase orders based on the purchase order requisitions, obtaining and registering purchase order confirmations, monitoring on-time deliveries and approving the purchase order invoices.

Each purchaser has an own activity code in the Target Company. The code is used when Spare part sales releases purchase order requisitions. The code directs the requisition to the correct purchaser. Purchase order requisition is created if stock availability is zero. Almost each product purchased by the Service's purchaser are backordered. It means a customer order that cannot be filled when presented (Backorder, 2018) and products are purchased after customer needs existed, purchases are reactively performed. In this case, more than 95% of purchase order lines were reactively performed in the period under review. As mentioned before, holding each product in a stock is not profitable business, but considering the primary goal of the Spare part business; to satisfy customer needs, I wonder if reactive purchasing is the most effective way to reach the primary goal. The question is, how to enable proactive purchasing that serves both parties in the most effective way?

Creating a purchase order through the ERP is simple to do and takes only a few minutes to be completed. This applies to products that are often purchased and suppliers are known. First steps are, selection of products that will be combined with the same order, and the supplier to whom the order will be targeted. Purchase order terms such as payment and delivery terms are given by the ERP. The details are set-up under supplier accounts, the account is created by the Finance department. Updating account information in the system is Project and Service purchasing responsibility. When placing an order, purchasers must choose which forwarder to use. In most cases, the selection is made between normal and express delivery.

If the order is addressed to an incorrect supplier, the order must be cancelled and requisitions lines must be created again to create new order for another supplier. The difficulty of choosing the correct supplier is due to ERP-setting proposing a primary supplier. The primary suppliers are registered for Project purchasing purposes and may not be reasonable to use for Service purchasing purposes. In the Target Company, the ERP is set

to serve the Project purchasing in the first place. The Service purchaser must question the proposals and manually check suitable supplier to use. When choosing a supplier, must be taken into account the criticality of the products under demand. Lowest costs are not always the most important factor but the cost and lead time together usually are. This selection is made manually, product by product, and based on the experience.

There are purchases in the Service business, which can be performed without a better knowledge of the business nor suppliers. I wonder, why the purchases are made as backorders by the Service purchaser, and why not by the inventory-managed -way by the inventory methods and set inventory parameters? Why to waste Service's purchaser's time to purchases that do not need any special knowhow or arrangements? I think that, these "easy products" should be identified and purchases should be handled automatically by the system. According to the author Sakki, businesses should target their activities so that the system to place the orders, and the purchasers to monitor the results and to make corrections for reaching the set goals. (Sakki 2014, 89)

Obtaining purchase order confirmations (OC) and monitoring on-time deliveries are performed manually via e-mail. Both functions could be handled by the ERP as well but the functionality has not been studied and no practical experience is available. OCs are registered to the ERP by confirming the purchase order with details the supplier has given. Service purchaser has an ERP list which shows the purchase orders that are not confirmed. By the list purchaser can monitor the situation. When creating a purchase order, the ERP system automatically inserts a comment to the order which guides the supplier to confirm the order soonest by an e-mail. The confirmations are requested to be sent to Purchasing's common e-mail box. The common e-mail box is red daily by the purchasers.

On-time deliveries are monitored also manually and inquiries are sent by e-mail. There is also a list available that can be used for monitoring. If the supplier informs delivery delays, the purchase order will not be confirmed by the new confirmed delivery date but the planned delivery date will be updated to match the new confirmed delivery date. This is how it's possible to see what has been the first confirmed delivery date and how many days the delivery has been delayed.

Purchase order invoice approvals are handled via ERP. The system informs by e-mail if invoices are waiting for approval. There's a link in e-mail message to click which leads

the approver towards ERP's invoice approval tool. This function requires that the ERP system is on and the approver is singed in. All invoices are not to be approved. Only the ones which has a difference between the invoice and the purchase order. The purchase order and the invoice must be matched, otherwise the finance department does not go forward with the payment.

5 Towards a Successful Inventory Management

"The main purpose of stocks is to give a buffer between supply and demand". (Waters 2009, 339.)

Inventories are, to mention a few functions,

- to provide availability of different kinds of products,
- to meet instant customer and manufacturing needs,
- to maintain wanted customer service level,
- to hold safety stock to buffer against uncertainty in demand, against supplier delivery time variability and against seasonal demand and supply,
- to take advantage of quantity discounts and buying costs,
- to provide a secure location for products

(Mangan & Lalwani 2016, 169; Rushton etc. 2012, 174; Scott etc. 2011, 85).

It is clear that inventories tie up money and holding stocks is an expense. According to my experience, in many companies, inventories are managed without proficiency and knowledge. Inventory management is not considered as an important part of a business because its effect is unknown. It is crucial that companies put effort on inventory management and control, and have an understanding where the capital is committed to and how it affects the business. By inventory management, the company's cash flow can be controlled in both directions.

In chapter 5, basic methods and tools for inventory management are presented. The methods in chapter 5.3 were chosen to be part of this thesis because these methods and tools can be deployed by the method A, even though the other methods in the Target Company's ERP won't be available for use during this work. This was decided because the implementation of a new ERP-method in the Target Company, proved to be very challenging and time-consuming, and requires participation of others, not just the researcher's.

5.1 Inventory turnover

The inventory turnover measures, on average, **how many times inventory is replaced over a period of time**. It is important measure since the **ability to move inventory quickly directly impacts the company's liquidity**

$$Inventory\ turnover = \frac{cost\ of\ all\ goods\ sold}{cost\ of\ average\ inventory\ held}, \quad (1)$$

(Mangan & Lalwani 2016, 168; Muller 2003, 30; Sakki 2014, 55; Salmivuori 2010, 83).

Calculation can also be done for **cost of goods sold from inventory only**, it is a more accurate measure of how many times actual physical inventory turned within the site

$$Actual\ physical\ inventory\ turnover = \frac{cost\ of\ goods\ sold\ from\ inventory\ only}{average\ inventory}, \quad (2)$$

(Muller 2003, 31).

When 365 is divided by the inventory turnover, an average time to sell the inventory is obtained. The obtained number also measures **days the inventory remains still**

$$Inventory\ turnover\ in\ days = \frac{365}{inventory\ turover\ ratio}, \quad (3)$$

(Sakki 2014, 56).

5.2 Stock profile figure

According to author Sakki, a figure of stock profile plays an important role in inventory management and control. Stock level variability and product availability can be viewed concretely from the figure. Conclusions of the supply capacity can be done through the figure as well. Also, the figure complements the average-based inventory control key-indicators, such as inventory turnover. (Sakki 2014, 71-80)

Questions listed below, can be discussed through the figure to get the starting point for successful inventory control.

1. Stock levels in right relation to the demand?
2. Right amount purchased?
3. Timely purchased?
4. Stock necessity?

(Sakki 2014, 80; Waters 2009, 338; Salmivuori 2010, 51)

5.3 Inventory control methods

One important function of inventory control is to determine the right time and the right amount to order (Hokkanen & Karhunen 2014, 207).

5.3.1 Safety stock

"Safety stock simply is inventory that is carried to prevent stockouts" (King 2011, 33). Safety stocks are kept to keep customer satisfaction on desired level. Safety stocks ensure availabilities. Potential sudden increases in demand, delays in supplier deliveries and inaccuracies in forecasting are prepared by keeping safety stocks. The need for safety stock caused by **variability in demand** can be evaluated based on standard deviation of demand.

$$Safety\ stock = ks\sqrt{L}, \tag{4}$$

In the above equation k is standard score, s is standard deviation of demand and L is lead time (total delivery time). (Sakki 2014, 83)

According to my understanding, in Sakki's above equation (3) the period under review to calculate standard deviation of demand (s) is assumed to be the same as lead time (L). Meaning, if the total lead time is four weeks the period under review is also four weeks. In practice, these rarely are the same. The conclusion is derived from author King's writing in APICS magazine "Understanding safety stock and mastering its equations".

$$Safety\ stock = Z\sqrt{\frac{PC}{T_1}}\,\sigma_D, \tag{5}$$

In the above equation Z is standard score, PC is performance cycle (total lead time), T_1 is time increment used for calculating standard deviation of demand and σ_D is standard deviation of demand. (King 2011, 34) The King's above equation (4) is closer to a real life, with the review period and performance cycle rarely equal.

Above two equations consider the variability of demand, although the variation may also occur in lead time. When the **variability in lead time** is the primary concern, according to author King, the safety stock equation (5) becomes:

$$Safety\ stock\ = Z\sigma_{LT}D_{avg}, \tag{6}$$

In the above equation Z is standard score, σ_{LT} is standard deviation of lead time and D_{avg} is average demand. (King 2011, 34)

When both **demand variability and lead time variability** are present, King demonstrates two alternative equations (6 & 7) for combined safety stock equation. In cases where the **variabilities are independent** the combined safety stock equation becomes:

$$Safety\ stock = Z\sqrt{\left(\frac{PC}{T_1}{\sigma_D}^2\right) + (\sigma_{LT}D_{avg})^2}, \tag{7}$$

In cases where the **variabilities aren't independent** the combined safety stock equation becomes:

$$Safety\ stock = \left(Z\sqrt{\frac{PC}{T_1}}\sigma_D\right) + \left(Z\sigma_{LT}D_{avg}\right), \tag{8}$$

The standard score (Z and k) mentioned above is a statistical figure that complies with the desired cycle service level.

Table 3. Standard scores (King 2011, 34; Sakki 2014, 83)

Desired cycle service level (%)	Standard score
84	1
85	1,04
90	1,28
95	1,65
97	1,88
98	2,05
99	2,33
99,9	3,09

5.3.2 Order point

Order point is a predefined product amount in stock when a new order to be placed. (Rauhala 2011, 181; Sakki 2014, 84; Ståhl 2014, 65; Tilauspiste) As can be deduced from the equations below, in an ideal situation, the safety stock is still available when goods of a new order arrive at the warehouse. If the lead time's demand has been more than predicted, the customer needs can be covered from the safety stock, as well as the defaults in the supply chain. Order point is calculated by the below simple equation (8) where D is time unit's average demand in goods unit and L is lead time in weeks.

$$Order\ point = DL + safety\ stock, \tag{9}$$

The **ordering period** may also be included in order to calculate the order point. In cases the order point equation (9) becomes:

$$Order\ point = D\left(L + \frac{P}{2}\right) + safety\ stock, \tag{10}$$

P is ordering period in weeks.

5.3.3 Min-Max

Minimum-Maximum (min-max) planning method can be used in cases a stock level is wanted to move between two predetermined values (levels, pieces, euros, etc.). If stock level remains between the values, no order will be released. (Sakki 2014, 85) The minimum value is a stock level that triggers a reorder and the maximum value is a targeted stock level that follows with the reorder (Vermorel 2014).

$$Min\ value = order\ point = lead\ time\ average\ demand + safety\ stock, \quad (11)$$

$$Max\ value = safety\ stock + order\ period\ and\ lead\ time\ demand, \quad (12)$$

Above two equations (10 & 11) are author Sakki's origin. (Sakki 2014, 85)

5.3.4 Right amount, proper time

By Wilson's formula (12), commonly known as an economical order quantity, EOQ, the order amount can be optimized (Choi 2014, 6; Sakki 2014, 86-87; Salmivuori 2010, 52-53).

$$Economical\ order\ quantity = \sqrt{\frac{2DS}{H}}, \quad (13)$$

D is assumed annual demand in units, S is fixed flat costs per order and H is annual holding, inventory cost per unit (unit cost multiplied by yearly inventory cost percentage). (Sakki 2014, 86)

EOQ-formula is suitable for optimizing the ordering amount of products with

- a fairly steady and predictable demand and
- a purchase cost that does not change substantially overtime and
- a stable inventory and ordering costs and
- an invariable lead time

(Salmivuori 2010, 52-53).

In cases, a supplier supplies more than one product to a company, adding products into the same purchase order is sensible and cost-effective. By Wilson's formula, the proper ordering period can be calculated. According to author Sakki, the biggest expense is associated with shipping of goods, so its worth of finding out, in how many shipments the annual need should be divided to.

$$Order\ period = \sqrt{\frac{2\,TK}{VK\,D}}, \tag{14}$$

TK is a cost for one shipment (cost of freight + cost of purchasing + cost of handling goods receipt), VK is an inventory cost percentage and D is an aggregate value of annual need of the supplier's all products. (Sakki 2014, 87)

5.3.5 Scrap the dead stock

Very often at my work, I'm in a situation, where I'm arguing against the opinion that any of existing stock should not be disposed, even if the products in stock hasn't been used in years. Most commonly I've been told that we might use the products someday and there's a plenty of room in Inventory to keep them and also the products are already paid, so why to dispose. My opinion is that all the products that accumulate costs only and have no intended use or sale, should be disposed. The question is where to draw the line? When a product is disposable?

<table>
<tr><th>Issue</th><th colspan="3">Arguments</th></tr>
<tr><td rowspan="3">space</td><td rowspan="2">space utilization</td><td colspan="2">squares: an item’s length x its width</td></tr>
<tr><td colspan="2">cubes: an item’s length x its width x its height</td></tr>
<tr><td colspan="3">money: the squares being consumed by dead SKUs x rent per square</td></tr>
<tr><td rowspan="2">labour and machines</td><td>efficient utilization of resources</td><td colspan="2">measure and estimate the amount of direct labour hours that goes into moving the dead product out of the way in a month, divide it by four and multiply by number of operative weeks in a year</td></tr>
<tr><td colspan="3">money: the average hourly wage, including benefits x the annual labour number</td></tr>
<tr><td rowspan="4">costs</td><td>reduction of carrying costs</td><td colspan="2">the K factor represents the number of cents per inventory euro per year a company is spending to house its inventory, it is generally expressed as a percent</td></tr>
<tr><td>Traditional method: K factor = total annual costs/average inventory value x 100</td><td colspan="2">rule-of-thumb method: K Factor = 20% + Prime Lending Rate</td></tr>
<tr><td colspan="3">average inventory x dead stock% x K factor = annual carrying cost</td></tr>
<tr><td colspan="3">money: annual carrying cost x cross profit margin% = amount of money company would have to generate at an X% profit margin to have the funds to house the dead stock</td></tr>
</table>

Figure 4. Arguments in favour of disposing of dead stock (Muller 2003, 34-37)

The above arguments, given by author Muller, should help convince decision maker that “it’s gotta go”. According to author Myerson, ABC classification is also a useful tool for SKU optimization: “An analysis whereby ABC codes are assigned to determine candidates to be discontinued, scrapped, written off, or sold at a large discount” (Myerson 2014, 63). ABC analysis is presented in chapter 5.4.

5.4 Classification

I have learned that **customers expect an instant response to their needs**, especially in aftersales services. It is often assumed that the company **storages all the spare parts and is capable for immediate deliveries**. At the same time, the **trend is to minimize levels and invested capital in stocks**. In the business where customer satisfaction is wanted to be kept in a very high level and the number of supplied products is huge, product **classification helps to prioritize where the business should dedicate existing resources**. The classification gives guidelines for inventory planning and control. By the classification, it is easier to answer the question whether to stock or not. Although, the aim of classification is to improve inventory decision making (Syntetos etc. 2011, 12).

ABC analysis is a method used in many inventory systems to classify products. It is based on Pareto principle, 20/80 rule. **According to the rule, only a relatively few products typically generate a large percentage of sales or profits.** In the traditional ABC classification, the products are classified in three classes A, B and C based on the annual sales. A; 20% of items generate 80% of annual sales, B; next 50% generate 15% of sales and C; last 30% generate only 5% of sales. (Myerson 2015, 61-63; Sakki 2014, 61-64; Salmivuori 2010, 37-38; Ståhl 2014, 63; Syntetos etc. 2011, 13) There are also classifications in use with more than A, B and C classes (Synteos etc. 2011, 13).

The class A is considered as the most critical, to which products, existing resources should be dedicated the most. Still, this doesn't mean that the other classes are meaningless. There are products, in the other classes, which are very important to the business and/or the customers. The ABC classification emphases that handling the inventory control, the product pricing and the customer service should be done differently on each class (Myerson 2015, 62; Sakki 2014, 61).

ISSUE		**THOUGHS REGARDING THE USE**
value versus volume	Use sales, costs, margins (euros) instead of units (pieces)	A class without high volume inexpensive products
cutoffs	not always exactly 80/20 rule	usually not hard to determine the best cutoffs
location	multiple locations	perform ABC analysis by location
data	history versus forecast	it's somewhat subjective, but history data usually best to use

Figure 5. Realities of ABC classification for inventory (Myerson 2014, 62)

ABC analysis is **a focusing tool** to organize a large number of products and find out the diversities for resource sharing. **According to the business requirements, certain conditions or practices can be defined for the classes, for example in sales, purchasing and inventory control.** In the table 5, above, is a few realities given by author Myerson to consider when performing the ABC analysis.

5.4.1 Forecasting

According to the authors Syntetos etc., the ABC classification is a single-criterion scheme, based on ranking SKUs by demand volume or demand value, split into three classes. For each class different service level is targeted. Classification done by the demand value, generates highest criticality to the class A and thus requiring the highest

service level to avoid backlogs. According to another argument, the class C should get the highest service level to avoid stock outs on relatively inexpensive SKUs in inventory. In summary Syntetos etc. notes that **neither demand-value nor demand-volume criterion has been developed from inventory perspective**. (Syntetos etc. 2011, 13-15)

The ABC classification does not take forecasting into account. Faster-moving SKUs are commonly forecast using time-series methods, but for items that are with lumpy demand, time-series may not work. Problem is that the classification scheme based on demand value or demand volume does not consider **demand rate**. Authors notes that a better approach to classify items in a manner that facilitates the choice of appropriate forecasting method. The authors identified two key classification criteria:

1. the degree of intermittence in demand
2. how erratic demand is when it occurs

(Syntetos etc. 2011, 13-15).

6 Optimizing & Implementing

6.1 Product group and goals for optimization

The purpose of inventory management is to know in a timely manner how many pieces each product is at each inventory location. For a successful inventory management following things are to be known: location of the goods, amount of the goods, arrivals and dispatches of the goods, availabilities and needs of the goods, amount of incoming goods and whether stock amounts and set stock levels are in right balance. (Ståhl 2014, 55-56)

Since it was not possible to optimize the entire Service stock within the thesis, the scope was limited to one specific product group. The product group was created to contain same kind of products which were to be stored and were to be purchased from the same supplier. Annual needs between different products in the product group were variable and therefore, different ways to control stock were needed for optimization. The product group contains 34 products. More information about the product group is in appendix 1. The appendix 1 is not published because it contains company confidential information.

The objectives for inventory management and its control were derived from the key performances of the Target Company's Spare part business. There are different KPIs set to measure the effectiveness and to guide the actions in spare part function. The status of the KPIs are monitored in weekly basis and reported monthly. Two of the KPIs are related to product availability and therefore directly effect on inventory management and stock control. More information about the KPIs are in appendix 1. The appendix 1 is not published because it contains company confidential information.

When planning inventory availability, it must be taken into account that usually customer's spare part orders are combined orders of different products. In this case, even if the SKUs are all available from stock, it doesn't mean that the 100% of customer orders are delivered on confirmed date or on-time. The confirmed delivery date depends on the other products that are combined in the same customer order. Basically, the KPIs are not directly usable in inventory availability planning but they can be taken for guidance.

The Spare part business' main purpose is to serve the customers in the best possible way. From inventory management perspective, the purpose is filled by ensuring stock

availabilities of demanded products. Of course, all spare parts are not to be stored but the ones which are important to customers. One other thing to keep in mind when planning the availabilities is that stocks are to be kept also to serve the Target Company's business in the best possible way. Storing goods means fast invoicing from receipt of customer order, but on the other hand, storing is always a cost and binds money. Finding the right balance is the best solution for keeping the businesses running (customers' and the Target Company's). The more efficient the inventory management and the purchasing activities are, the better the customer satisfaction will be, and the continuity of the business is ensured. All this has a bearing on customer satisfaction, and good customer satisfaction will promote more trade in the future.

6.2 Inventory availability planning

A goal of acquisition is to buy the right amount of the right quality at the right time at the right price from the right provider to the right place (Ståhl 2014, 90). This is a classic, passive, reactive understanding of procurement and purchasing. One of my personal goal as a purchaser is to enable proactive purchasing. To be able to proactively take action and get benefits of upcoming changes in business environment and supplier field, instead of adapting to the changes that have already happened and just settling for them. (Iloranta etc. 2015, 95)

To reach the goal above, the amount of purchaser's operational work is to be reduced. It can be done by the inventory-managed purchasing so that stock availability meets the future demand;

- the SKUs are identified,
- inventory availability planning parameters that guide the SKUs' acquisition are optimized, and
- order proposals and order placing are handled automatically by ERP system.

It is clear that all the operational purchasing work can't be, neither wanted to be, led by the inventory management, but **should be used when appropriate and reasonable**.

After each products visualization (chapter 6.3; appendix 2), I divided the products into groups based on the results of optimization. The product groups are presented in chapter 6.4. The products that had no demand in 2016 and 2017, and despite the fact that these

products should be stored, I decided to give my recommendation to the management that these products will no longer be stored for just in case. In case of a demand, the product will be purchased with the requested quantity and by express delivery. By express delivery, we are able to reduce the total lead time in weeks, if the order amount is not more than ten pieces. Express delivery is a lot more expensive, but this could be taken into account on sales pricing. According to this, following products will be purchased after the demand has occurred and the requested amount only, no storing allowed. The products are product1, product14, product25, product27, product33, product3 and Product16. This rule was implemented to the Target Company's ERP on March 2018. Now the system gives a purchase requisition of requested quantity when the sales releases the customer order. Now purchasing doesn't have to use time to find out whether to store the product or not and how many pieces to purchase. The EOQ formula (13) presented in chapter 5.3.4, is not used as a planning method in this paper because none of the products contained the conditions required for the use.

6.3 Visualizing

To get a better understanding of the products' nature, I decided to make figures of stock profiles of each product. Stock profiles present product's stock level movements and transactions in and out in 2016 and 2017 (figure 6). Data, to make profiles, were gathered from the Target Company's ERP system on 18th of February 2018. The illustration of the stock profile figures were inspired by author Sakki (Sakki 2014, 78-79). The stock profiles are presented in appendix 2.

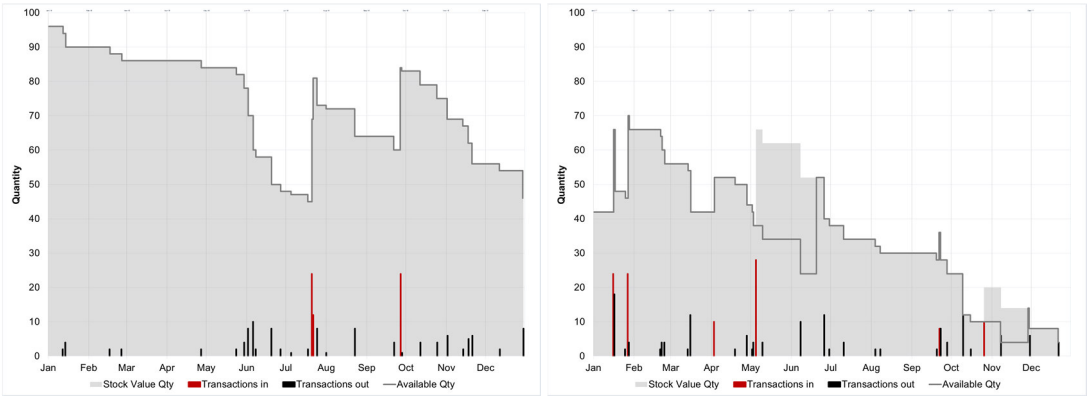


Figure 6. Stock profiles example, 2016 and 2017

There were 34 products in total in the part group as mentioned before. Some of the products didn't have any transactions during the years. These products weren't visualized. Two of the products had only transactions in, no demand occurred over the reference period. These products weren't visualized either. 27 products in total were visualized and presented in appendix 2.

Questions listed below, were discussed through the profiles after each figure. The discussion and conclusions are presented under each figure in appendix 2. The questions were set to get the starting point for a successful inventory control.

1. Stock levels in right relation to the demand?
2. Right amount purchased?
3. Timely purchased?
4. Stock necessity?

(Sakki 2014, 80; Waters 2009, 338; Salmivuori 2010, 51).

In a table after each figure's discussion and conclusions, basic data is presented and calculated to support inventory availability planning. The table data was gathered from the Target Company's ERP system on 18th of February 2018, and calculated and/or analyzed with previously presented methods in chapter 5 or as presented in below table 4. SKUs' inventory values are company confidential information, and therefore, the values are not published.

Table 4. Basic data, visualization example

	2016	2017	
annual demand, pcs	110	142	gathered from the ERP
average of yearly stock, pcs	72,25	32,5	average calculated with end of month stock levels
highest yearly stock, pcs	96	70	gathered from the ERP
lowest yearly stock, pcs	45	4	gathered from the ERP
SKUs inventory value, euros	1000	1000	gathered from the ERP
inventory turnover ratio	1,52	4,37	calculated as presented in 5.1.
inventory turnover, days	240,13	83,52	calculated as presented in 5.1.
cycle inventory, pcs	10	17,33	half of the average size of order batch received (Sakki 2014, 73)
passive inventory, pcs	36	0	refers to the actual stock level of a review moment deducted by the cycle inventory (Sakki 2014, 73)
standard deviation of demand, pcs	2,72	4,18	refers to the standard deviation of demand's individual observations from the demand's average value of the same product (Sakki 2014, 83)

As an example, table 4 presents the data of figure 6. You may wonder why safety stock levels are not presented at this point. It is because the method has not properly been used in the Target Company and the visualization chapter indicates a situation in the past. Safety stock levels are calculated later in this chapter for the future inventory control. Average of yearly stock is calculated with end of month stock levels because in the Target Company the review period is set up as one month. More accurate number would be reached if review period was changed to a week or a day. In my opinion, the monthly review period is accurate enough when reviewing the number of transactions as shown in the figure 6. SKUs inventory value is presented to calculate inventory turnover by product. Cycle inventory and passive inventory are presented because they will be referred into inventory optimization and inventory availability planning. In table 4, the passive inventory is estimated with the ending stock level of the year. Standard deviation of demand is presented for calculating safety stock levels in following chapter.

6.4 Simulating Order point -method

This Order point -method simulation was performed instead of Order point -method implementation. The implementation of Order point -method would have been performed directly to the Target Company's ERP system but the way of acquisition was changed and the method wasn't suitable anymore to use. Without the change, the Order point -

method would have been chosen to perform inventory control and inventory-managed purchasing.

The simulation should have been done anyway since the results can be analysed not until the implemented stock control method and its parameters have been in use for about a year. This is because the nature of the demands is intermittent and lumpy. This simulation was done to investigate how the optimization would have affected the inventory levels in 2017 and to get indicative results and conclusions of the performed optimization. The Order point -method will be taken in use in the Target Company but not for the product group.

The output data for this simulation was gathered from the Target Company's ERP system. The data of 2016 was used to optimize the inventory of 2017. The calculations in the optimization were performed using only data that was available in the end of 2016 to achieve realistic results and conclusions from the simulation.

Safety stock levels were calculated based on the equation in which the demand is considered as variable and variability of lead time is not taken into account because in this case it is invariable. Therefore, the other introduced safety stock equations (4, 6, 7 and 8) were not chosen. The chosen safety stock equation (5) is introduced in chapter 5.3.1 as well the others. Order points were calculated based on the equation (9) introduced in chapter 5.3.2. Order quantity was defined in this simulation to match the lead time's average demand.

Based on the results of the optimization, the products were divided in four groups named Orange (6.4.1), Yellow (6.4.2), Blue (6.4.2) and Green (6.4.3). The reasons for the division can be found in the chapters. In each chapter, simulations are presented with tables. The tables contain of three different sections. The first section, grey-section, contains the results of the optimization i.e. the stock control parameters, and a total demand in 2016 -figure that was used for calculating the parameters. Presented parameters are safety stock, order point and order quantity. The second section, white-section, contains information related to purchasing and the actual figures in 2017. Purchasing related information is products minimum order quantity and a multiple lot size. The actual figures contain the figures of total demand in 2017, average yearly stock level in 2017 and inventory turnover rate in 2017. The last section, which is colored after the group name, contain results of the simulation. Presented results are yearly stock optimized, inventory

turnover optimized, inventory turnover change and average yearly stock value change. Group chapters are followed by Results -chapter where the results of the simulation are introduced and summarized (Chapter 6.5.1).

6.4.1 Orange

This chapter deals with products of which stock control was performed using the Order point –method. Stock control parameters were reviewed quarterly.

Group Orange consists of products with **cyclical demand**, calculated **safety stock level** as well as **total demand in 2016 was more than zero** and calculated **order quantity was more than minimum order quantity**.

In table 5 products with cyclic demand are listed with values.

Table 5. Cyclic demand

Poduct	Total Demand 2016	Safety Stock	Order Point	Order Quantity	Min. Order Quantity & Multiple Lot Size	Total Demand 2017	Average Yearly Stock 2017	Inventory Turnover 2017	Average of Yearly Stock Optimized	Inventory Turnover Optimized
product2	110	17	32	16	4	142	32.5	4.37	7.67	18.51
product7	10	2	4	2	2	10	10.67	0.94	7.17	1.39
product11	48	10	17	6	2	42	16.83	2.50	11.33	3.71
product12	13	4	Q2: ~~6~~ 16	~~2~~ 12	2	69	21.33	3.23	20.83	3.31
product13	68	8	17	10	2	73	21.67	3.37	11.50	6.35
product15	67	11	20	10	2	38	28.17	1.35	22.83	1.66
product21	22	3	6	4	2	20	5.42	3.69	4.25	4.71
product23	9	2	3	2	2	8	1.67	4.79	3	2.67
product26	5	2	2	2	2	3	0.67	4.48	2.67	1.12
product34	94	13	25	14	4	78	9.33	8.36	15.42	5.06

Products in table 5, total ten pieces, were all simulated as the Order point -method would have controlled the purchasing in 2017. Meaning the stock control parameters; safety stock, order point and order quantity, remained as they were calculated (optimized) in the first place. Only one exception done with the product12. Order point and order quantity parameters were reset in the beginning of Q2 because in the quarterly monitoring would have been observed that the demand of the first quarter was more than the total demand in 2016. Updated parameters were calculated based on the first quarter in 2017.

6.4.2 Yellow and Blue

This chapter deals with products of which stock control was performed using the Order point –method. Stock control parameters were reviewed twice a year.

Group Yellow and Blue consist of products that calculated **stock control parameters were zero or** calculated **order quantity was less that minimum order quantity** and **total demand in 2016 were more than zero.**

In table 6 products with predictable demand are listed with values.

Table 6. Predictable demand

Poduct	*Total Demand 2016*	*Safety Stock*	*Order Point*	*Order Quantity*	*Min. Order Quantity & Multiple Lot Size*	*Total Demand 2017*	*Average Yearly Stock 2017*	*Inventory Turnover 2017*	*Average of Yearly Stock Optimized*	*Inventory Turnover Optimized*
product5	*4*	*0*	*0*	*2*	*2*	*0*	*6.25*	*stocked with no profit*	*2*	*stocked with no profit*
product31	*4*	*0*	*0*	*2*	*2*	*5*	*0.97*	*5.15*	*1.25*	*4.12*

Table 6 consists of two products, group Yellow. Stock control parameters were reset before the simulation because calculated parameters were: safety stock = 0, order point = 1 and order quantity = 1, and since the minimum order quantity for both product was two pieces, I changed the order quantity to two pieces. Calculated order point was one piece, but since the total demand in 2016 per product, was four pieces and in 2016 customers ordered two pieces at a time, I decided to change the order point to be zero. Parameters used in the simulation were safety stock = 0, order point = 0 and order quantity = 2. It means that the products would be purchased when the stock levels reach the zero. I assumed that the products would be purchased in batches of two pieces also in 2017 and that the demand can be called as “predictable demand”. No changes done over the monitoring periods.

In table 7 products with erratic demand are listed with values.

Table 7. Erratic demand

Poduct	Total Demand 2016	Safety Stock	Order Point	Order Quanti ty	Min. Order Quantity & Multiple Lot Size	Total Demand 2017	Average Yearly Stock 2017	Inventory Turnover 2017	Average of Yearly Stock Optimized	Inventory Turnover Optimized
product4	2	0	0	2	2	0	2	stocked with no profit	2	stocked with no profit
product6	1	0	0	2	2	0	0	no stock	2	stocked with no profit
product8	1	0	0	2	2	1	0.5	2.00	1.33	0.75
product9	1	0	0	2	2	2	0.5	4.00	1.33	1.50
product10	2	0	0	2	2	0	1.5	stocked with no profit	1.83	stocked with no profit
product18	2	0	0	2	2	1	1.67	0.60	1.67	0.60
product19	3	1	1	2	2	4	0.58	6.90	1.5	4.60
product22	2	0	0	2	2	1	1.67	0.60	1.25	0.80
product24	1	0	0	2	2	3	0.83	3.61	1	3.00
product29	2	0	0	2	2	0	1.5	stocked with no profit	1.83	stocked with no profit
product30	2	0	0	2	2	1	2.58	0.39	2.58	0.39
product32	2	0	0	2	2	2	0.17	11.76	1.5	1.33

Table 7 consists of 12 products, group Blue. The difference between the Blue and the Yellow is that the demand in Blue is not predictable, so it's called "erratic demand", and

the results of made calculations achieving parameters, were less than one in all figures. As mentioned, calculated order points were zero but since the total demand in 2016 by product was more than zero, I decided to make an assumption that the products would have demand also in 2017. I decided to set the safety stocks and order points to zero and order quantities according to the minimum order quantity which is in these cases two pieces. This means that when the stock level reach the zero the order will be created for two pieces. In other words, there will be stock or at least new purchase order released all the time. There is one exception in the Blue group, product19. Calculated parameters were safety stock = 1,30, order point = 0,70 and order quantity = 0,40. I changed them to be safety stock = 1, order point = 1 and order quantity = 2. No changes done for Blues over the monitoring periods.

6.4.3 Green

This chapter deals with products of which stock control was performed using the Order point –method. Stock control parameters were reviewed twice a year.

Group Green consist of products that **total demand in 2016 was zero.**

In table 8 products with zero demand are listed with values.

Table 8. No demand

Poduct	Total Demand 2016	Safety Stock	Order Point	Order Quantity	Min. Order Quantity & Multiple Lot Size	Total Demand 2017	Average Yearly Stock 2017	Inventory Turnover 2017	Average Yearly Stock Optimized	Inventory Turnover Optimized
product1	0	0	received CO	CO/min o.qty	4	0	0	no stock	0	no stock
product3	0	0	received CO	CO/min o.qty	4	0	1.5	stocked with no profit	0	no stock
product14	0	0	received CO	CO/min o.qty	2	0	0	no stock	0	no stock
product16	0	0	received CO	CO/min o.qty	2	0	1.5	stocked with no profit	0	no stock
product17	0	0	received CO	CO/min o.qty	2	2	0.17	stocked with no profit	0	no stock
product20	0	0	received CO	CO/min o.qty	2	2	1.17	1.71	1	2
product25	0	0	received CO	CO/min o.qty	2	0	0	no stock	0	no stock
product27	0	0	received CO	CO/min o.qty	2	0	0	no stock	0	no stock
product28	0	0	received CO	CO/min o.qty	2	1	0.58	1.72	0.42	2.38
product33	0	0	received CO	CO/min o.qty	2	0	0	no stock	0	no stock

Table 8 consists of 10 products, group Green. Optimization performed by the Order point -method weren't possible for the Greens since there was no demand at all in 2016. Even though the products should be stored, I decided not to do that and release the purchases only after the receipt of a customer order (CO). Then, the purchase order quantity depends on the customer order amount and/or the minimum order quantity (CO/min.o.qty). At the same time, I made a decision that possible customer needs are not to be met immediately.

6.4.4 Results

In this chapter, the results of the simulation are presented. The metrics for measuring the results are described in chapter 3.1. It can be assumed that by using the Order point -method in the future, the results will be equivalent with the simulation. The results are presented in percentages instead of actual values for company confidentiality reasons.

Table 9. Achieved results of Optimization.

Product	Instant Customer Delivery Change	Change in Time Spent on Purchasing	Inventory Turover Change	Average Yearly Stock Value Change
product2	-11 %	-68 %	324 %	-76 %
product7	0 %	-60 %	49 %	-24 %
product11	0 %	-40 %	49 %	-23 %
product12	13 %	-70 %	2 %	-2 %
product13	5 %	-53 %	88 %	-40 %
product15	0 %	-40 %	23 %	-8 %
product21	29 %	-67 %	28 %	-11 %
product23	0 %	0 %	-44 %	80 %
product26	0 %	-80 %	-75 %	299 %
product34	18 %	-70 %	-39 %	65 %
product5	no demand	-100 %	stocked with no profit	-68 %
product31	0 %	-85 %	29 %	29 %
product4	no demand	-80 %	stocked with no profit	0 %
product6	no demand	100 %	stocked with no profit	100 %
product8	100 %	-80 %	-62 %	166 %
product9	100 %	-80 %	-62 %	166 %
product10	no demand	-80 %	stocked with no profit	22 %
product18	0 %	0 %	0 %	0 %
product19	-50 %	-60 %	159 %	194 %
product22	0 %	-90 %	34 %	-25 %
product24	50 %	-87 %	-17 %	20 %
product29	no demand	-80 %	stocked with no profit	22 %
product30	0 %	0 %	0 %	0 %
product32	100 %	-80 %	-89 %	782 %
product1	0 %	0 %	no stock	0 %
product3	0 %	-100 %	no stock	-100 %
product14	0 %	0 %	no stock	0 %
product16	0 %	-100 %	no stock	-100 %
product17	0 %	-90 %	no stock	-100 %
product20	0 %	-90 %	17 %	-15 %
product25	0 %	0 %	no stock	0 %
product27	0 %	0 %	no stock	0 %
product28	0 %	-100 %	38 %	-28 %
product33	0 %	0 %	no stock	0 %
Totals by Optimized Inventory				
Stock Keeping Units				
-7 %				
Instant Customer Deliveries				
92 %				
Purchases Spent Time Change, Average				
-54 %				
Inventory Turnover Change, Average				
21 %				

As often mentioned over this paper, the purpose of the spare part business is to serve the customers as efficiently and good as possible. The product availability plays a very big role in customer satisfaction. Using the Order point -method, 92% of customer orders could have be delivered instantly from the stock. In other words, customer service for customer deliveries improved by six percentage points. In table 9 there are two products of which stock availability has got worse. In both cases, the lack-time was significantly shorter than the product's purchasing lead time. Meaning that purchase orders were released before the CO was received.

Totally 34 products were optimized and simulated (tables 6, 7, 8 and 9). In 2017, 28 products were stocked from 34 products. With the optimization, the stored amount of products would have been 26 (table 9). Two products less to stock, optimize, purchase, handle and monitor. 19 of 34 products had demand in 2017, and inventory turnover could be calculated. In 12 cases inventory turnover improved. As mentioned before, the turnover rate indicates the efficiency in stock rotation. Overall, the inventory turnover improved by 21%.

If the stock control parameters would have been set up as previously introduced and purchases would have been placed as proposed by the Order point -method, the average inventory value in 2017 for this specific product group would have been 7% lower (table 10).

Table 10. Average inventory value change, %.

Average Inventory Value Change	
Group Orange	-10 %
Group Yellow	-39%
Group Blue	+37%
Group Green	-60%
Total	**-7%**

The differences between the optimized product groups were as follows: Orange, -10%, Yellow, -39%, Blue, +37% and Green, -60% as presented in table 10.

Workload meaning the spent time on operational purchasing in this specific product group was difficult to figure out. Estimated time spent per purchase order line was conservatively evaluated as well as estimated time that would be spent per purchase order line after optimization. Despite the conservative estimates, the average change in spent

time was reduced by 54%. It is worth noting that it was assumed here that, after optimization, there was no longer need for checking ordering amounts and ordering time for orders, but purchase orders could be released of system generated purchase proposals without a greater consideration.

6.5 Adapting the new way of acquisition

Since the Target Company changed the way of acquisition of the specific product group, a new plan for stock control was needed. In this chapter, a plan for handling purchasing and stock levels are presented. The plan was implemented to Target Company's ERP system but there was no time to get all the results measured that were set in the beginning of the thesis. Due to the high variability and low volume of the demand the results can be seen reliably not until the set stock control parameters have been operated for several order periods, preferably at least one year. The available results are presented in chapter 6.5.1.

Unfortunately, the new way of acquisition cannot be descripted for company confidential reasons. Anyhow, the Order point -method is not viable way to perform stock control and purchasing because purchases should be done more rarely. When taken into consideration supplier's manufacturing capacity, the aim of reduction of operational purchasing work and its facilitating, it was decided that purchases will be combined and placed in every two months, six times per year. Meaning, the stock control parameters had to be adapted to the periodical purchasing. It is worth noting that, following the company's service strategy, the availability of the products has been prioritized at the sacrifice of the capital invested in the stock. The plan was made so that the levels are optimized against the needs and with the assumption that the products in stock rotate. Stock control parameters are presented in table 11.

The calculated stock control parameters in table 11 follow the demand in 2017, meaning for example, the demand in 2018 is predicted to be as it was in 2017. Here is also assumed that the purchasing lead time is invariable and therefore the safety stocks are calculated using the same equation (5) as before in this paper. Order quantity, in this case maximum order quantity, is calculated as follows: total demand in 2017 divided by 52 weeks (52 weeks in a year) and multiplied by 8,67 weeks (52 weeks in a year divided by 6 orders in a year).

Table 11. Inventory control parameters for 2018

Poduct	*Total Demand 2017*	*Safety stock 2018*	*Maximum Order Quantity*
product1	0	0	0
product2	142	20	44
product3	0	0	0
product4	0	0	0
product5	0	0	0
product6	0	0	0
product7	10	4	5
product8	1	1	1
product9	2	1	1
product10	0	0	0
product11	36	11	17
product12	69	14	25
product13	51	7	16
product14	0	0	0
product15	40	10	16
product16	0	0	0
product17	2	2	2
product18	1	1	1
product19	4	2	3
product20	2	2	2
product21	14	5	8
product22	2	1	1
product23	8	3	4
product24	4	2	3
product25	0	0	0
product26	3	1	2
product27	0	0	0
product28	1	1	1
product29	0	0	0
product30	1	1	1
product31	5	2	3
product32	1	1	1
product33	0	0	0
product34	78	24	37

This method of optimization adjusts partly previously presented Min-Max -method in chapter 5.3.3. In this case the stock levels are wanted to move between two predetermined values. The Max-value is maximum order quantity and Min-value is safety stock value. Since the purchases will take place in every other month the goods are received also in six times per year. When the order is placed, the ordering quantity is determined by subtracting from the maximum order quantity the current stock balance. This way the stock will be refilled to meet the demand.

6.5.1 Results

The results of the implementation for the specific product group for year 2018 using the Order period -method are presented in this chapter. The metrics for measuring the results are described in chapter 3.1.

Table 12. Placed orders in Q1, 2018

Poduct	*Beginning stock in January 2018*	*Beginning stock in March 2018*	*Ordered in January 2018*	*Ordered in March 2018*
product1	0	0	0	0
product2	4	0	40	44
product3	2	2	0	0
product4	2	2	0	0
product5	8	8	0	0
product6	0	0	0	0
product7	7	5	0	0
product8	1	1	0	0
product9	2	2	0	0
product10	2	2	0	0
product11	7	7	10	10
product12	44	36	0	0
product13	13	7	3	9
product14	1	1	0	0
product15	12	8	4	8
product16	2	2	0	0
product17	2	2	0	0
product18	1	1	0	0
product19	0	0	3	3
product20	3	3	0	0
product21	2	2	6	6
product22	4	4	0	0
product23	0	1	4	3
product24	2	2	1	1
product25	0	0	0	0
product26	5	5	0	0
product27	0	0	0	0
product28	2	2	0	0
product29	2	2	0	0
product30	2	2	0	0
product31	5	5	0	0
product32	0	0	1	1
product33	0	0	0	0
product34	11	3	26	34

At this point the change in customer service cannot be measured. Still, it can be concluded that since the safety stocks and order quantities are calculated in accordance

with the simulated Order point -method, using trammels of the new way of acquisition, and the same service level 95% used in calculations, the results will be comparable. In other words, customer service will be improved and shown by less delayed customer order deliveries in the future.

Annual inventory turnovers as well as average yearly inventory values cannot be measured at this point because the Q1 is still affected by the purchases done or not done in 2017. However, it is assumed, that the inventory turnovers and inventory values compared to the 2017 will be more compatible to the needs than in 2017.

The work load, meaning the spent time on operative purchasing was difficult to figure out. Estimated time spent per purchase order line was conservatively evaluated as well as estimated time that would be spent per purchase order line after optimization. Despite the conservative estimates, placing purchase orders in 2018 for the specific products following the new way of acquisition the spent time per purchase order line is one fifth, it is 80% less than before.

With the new way of acquisition, the load of operative purchasing work decreased and by the set stock control parameters the operative purchasing facilitated a lot. Now there will be only six orders per year and the order proposals will appear directly from the ERP system based on the set stock control parameter. When placing the order the purchaser much check the ordering amount, since the system propose the maximum order quantity to be ordered, but the right order quantity is the maximum order quantity minus the current stock quantity. This is very easy and fast to check and correct when ordering because the system allows direct view by two “cliks”. This scheduled replenishment level -method should also be possible to perform in the ERP but there was no time to investigate the functionality and therefore the parameters were set to the system using the A-method.

6.6 Conclusions

The decisions taken in the inventory management and its control influence directly to the business result and it can be seen to be relevant also for the business continuity. By inventory optimization, customer service and customer satisfaction can be improved. Product availabilities are handled by the inventory management and when the stock levels are in right relations to the demand, the customer needs can be met instantly and

customer satisfaction is guaranteed. This requires transparent co-operation between the customers, the Target Company and the suppliers.

Inventory optimization is a useful tool to reduce the operative purchasing work load. When stock control parameters are carefully calculated, order placing requires a lot less back up work, especially when the parameters are set into the ERP system and the system generates the order proposals within the suitable periods.

Normally, companies are not pleased to invest money into the stock. By inventory optimization the value of committed capital can be rationalized and reduced. Of course, the value of committed capital is always bind with the company strategy and customer expectations, actually balancing between them. By optimization the inventory, turnover can be improved and made sure that the products are not remaining still.

The inventory optimization is based on a statistical analysis and therefore it would serve better if there were large number of transactions to analyse. It is clearly evident in the literature that the available theories for inventory management and its control are to control large-scale business. It is hard to optimize stock levels in an intermittent and erratic demand. However, it must be noted that analysis is worth to be performed to realize where to use common sense instead of the statistical analysis.

Often the inventory optimization is seen as lower stock levels, smaller order quantities, smaller amount of placed orders, less committed capital, etc. Although the optimized state does not necessarily mean reductions from existing values. The purpose of the optimization is to enable the outcome which is needed to achieve the primary goal. For example, if the primary goal is to improve on-time customer order deliveries by 10% or reduce the average annual stock value by 10%, the optimization outcome could most likely be different. Usually, optimization seeks more than one outcome at the same time or state that serve more than one intent simultaneously, resulting in a compromise. In summary, it is crucial to understand where to head and lead the functions to achieve the desired goals.

Inventory optimization using the Order point -method would have produced results for a better business. The committed capital would have been decreased, the inventory turnover would have been improved, the customer service would have been improved and the operative work load would have been decreased. It isn’t unusual that situations

change in the business life, as happed during this thesis, and a new way of acquisition was introduced to be used. At the same time it made the Order point -method inapplicable. However, the method will be taken in use in the future development of the inventory. In the Target Company, inventory management is constantly being developed and improved, and within this thesis a new position to improve and develop inventory functions was created and will be filled soon.

The way of acquisition defines the stock control method to be chosen. Since the acquisition method was changed, the method was chosen to serve the new way of acquisition. Min-Max -method was chosen to keep the stock levels in control and to enable periodic purchasing. Compared to the Order point -method, the load of operative purchasing work will be even lower with the Min-Max method because the periodical purchasing will be used. Since the purchases will be controlled by the stock control parameters in the future, the operative purchased doesn't have to wonder how many pieces and when the purchases should be placed. This releases the work load and availability planning will be on inventory management's responsibility. The purchaser can use the released time to handle purchases that are addressed directly to the purchasing.

6.6.1 Ideas for future development

In this chapter opportunities for the future development related to inventory management are presented.

The dead stock should be disposed. There are a lot of products in Service stock that should be scrapped. The arguments for favor of the disposal are presented in the chapter 5.3.5. It might be effective to calculate the amount of money lost when holding the dead stock.

Over three years I have been working in the Target Company, the analyses for what would be reasonable to stock have not been performed. During the three years the assignment related to inventory management was to reduce stock levels by avoiding stock refilling, and purchasing the products only against the demand. Since the primary goal is to serve the customers in the most effective and financially profitable way, I would do the analysis of what should be stored in customers' and in the business point of views, and seek for a solution to satisfy the both parties. With sensible and planned storing, we

can further reduce the workload of operative purchasing and control availabilities through inventory control methods.

When the SKUs are defined and suitable stock control methods are investigated and implemented, the stock can be further optimized, for example, by shortening the purchasing lead times, agreeing new and better payment methods, negotiating new and better purchase prices, sourcing new suppliers, developing new storage methods and places, etc.

When the Inventory contains products that actually belong there, the SKUs should be classified to enable more efficient and handy inventory management. Classification, as mentioned before, aims the product handling by categories so that the products in a class are treated in the same way. This way the existing resources can be addressed easier to those product classes that are the most commercially or financially relevant. The product classification is briefly discussed in chapter 5.4. For example, Service strategy -customized ABC analysis might be suitable to be performed for Service stock.

A big lack in Target Company's inventory management is that inventory costs and/or inventory holding costs are not known. It is crucial to find out how much it costs to hold the stock and what can be set as annual inventory interest for a single SKU. Also in inventory management's perspectives, the inbound logistical costs are to be defined too. When the costs are known, for example the calculation for cost-effective purchasing period can be done. The equation (14) is presented in chapter 5.3.4.

With exceptionally large customer order quantities in products that are delivered from stock, partial deliveries could be agreed with sales. This would help the inventory management to plan availabilities and remain the stock in reasonable levels. Also, it commits less money to stock, if the demand is less varied.

Product-specific sales analyses or sales forecasting has not been performed in any level, at least not in the last three years. Product-specific sales analysis would help Service purchasing to perform proactive purchasing, to define SKUs and to develop supplier relations. For example, the stock doesn't have to be located in our own premises but before making any decisions (moving storage to another locations), the sources of the demand should be known and analysed.

What comes to the sales forecasting, it should be carefully considered how it should be done. In the Spare part business making assumptions based on the demand of the previous years would be a good way to do it.

The most important thing is that when we have a lots of products in stock we should be able to make changes at short notice and respond to the changing demand effectively. We need to have a system that is easily manageable through the ERP system. In this way, we gain efficiency while the business is growing. At present, unfortunately often, processes control operations and activities, though it would definitely go the other way around.

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1. Object and goal

Not published.

Not published.

2. Visualized profiles and discussion

The part group consists of 34 products. All of them are named accordingly: product1, product2, product3, etc.
Some of the products hadn't any transactions during years 2016 and 2017, these products weren't visualized: product1, product14, product25, product27 and product33.
Product3 and Product16 had only transactions in, no demand occurred over the view periods. The products were wanted to keep in stock just in case of a demand. These products aren't visualized either.
Visualized products are product2, product4 - product13, product15, product17 - product24, product 26, product28 - product32 and product34. According to this, 27 products in total were visualized and discussed under this appendix.

2.1 Product2

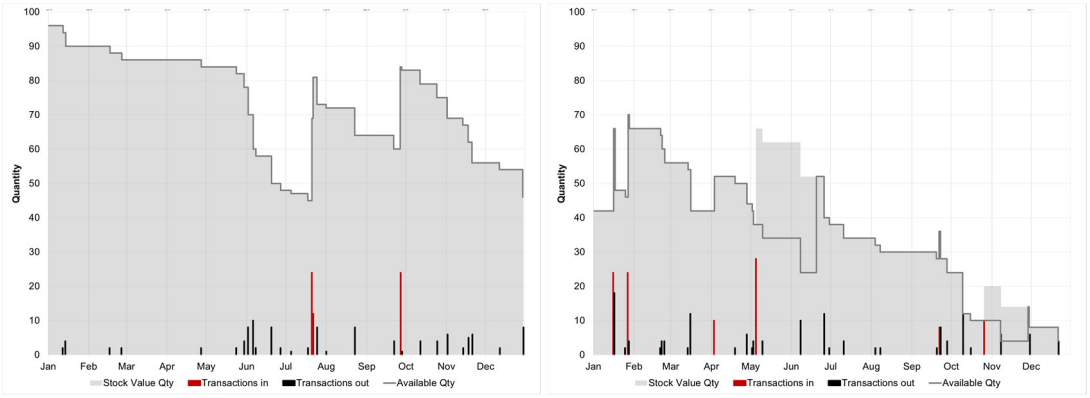

Figure 7. Stock profiles, product2; 2016 and 2017

1. Stock levels in right relation to the demand?
   It is easy to see by observing the figure 7 that in 2016 the product was stored over demand during the year. Overstock existed during the whole year. For example, by taking 44 pcs out from beginning stock on January 2016, the stock level with the transactions in, would have covered the demand without any lacks. (figure 7)

   Overstock existed also in 2017 but not that much as in 2016. As we can see, from the profile of 2017 in figure 7, overstock existed in the first half of the year. Mostly because of the two sequential inward transactions on January, and then again

on April and May. In the end of the 2017 the stock level was surprisingly low and stock required supplement. (figure 7)

In 2016 the nature of demand of Product2 was intermittent and lumpy. Forecasting the future demand for stock controlling purposes is challenging. In 2016, the transaction out happened 27 times and the product quantity per transaction out was between one to ten pieces. Until June 2016, there were a lot less demand than the rest of the year. The demand of 2016 was 110 pieces. 98 pieces occurred from June 2016. (figure 7)

In 2017, the situation was completely changed. At that time, the demand occurred on monthly basis. However, the product quantity per transaction out was more varied than a year earlier. During August 2017, the demand was on lowest and the next transactions out happened not until the end of September. In 2017, the transaction out happened 27 times and the product quantity per transaction out was between 2 to 18 pieces. The demand of 2017 was totally 142 pieces, compared to 2016 it increased by 32 pcs. (figure 7)

Of course afterwards, it is quite easy to analyse transactions and make conclusions of how the stock planning should have been done. If the demand is not steady, as it wasn't in this case, you have to prepare for intermittent and variable demand. Prepare by holding stock, stock levels based on forecasted demand.

2. Right amount purchased?

In 2016 transactions in held 60 pieces of products. As mentioned before, by taking 44 pieces out from the beginning stock in 2016, existing stock with the transaction in would have covered the demand. On the other hand, there were three transactions in holding 24, 12 and 24 pieces of the product. One transaction in holding 24 pcs would have covered the whole demand of 2016. (figure 7)

In 2017 transactions in was holding totally 104 pieces of the product. What comes to the demand of the year, 104 pieces was a right amount to be purchased to cover the demand. While, the timing and the order amounts wasn't. Shortly, too

many pieces in stock in the beginning and too few pieces in stock in the end of the year. Also, stock level in 2017 in the end of the year was too low. (figure 7)

3. Timely purchased?

   By one transaction in holding 24 pcs on October 2016 would have covered the demand without any lacks. A month later, it would have been too late and a shortage would have appeared. (figure 7)

   Obviously in 2017, there has happened some kind of an error in order placing and/or supplier delivering, since there where two sequential transactions in. Mostly transactions in took place in the beginning of the year, before June. Arrivals of the goods should have been more smoothly planned during the year. (figure 7)

4. Stock necessity?
   Yes.

Basic data of product2 summarized in table 13.

Table 13. Basic data of Product2

	2016	2017
annual demand, pcs	110	142
average of yearly stock, pcs	72,25	32,5
highest yearly stock, pcs	96	70
lowest yearly stock, pcs	45	4
SKU inventory value, euros		
inventory turnover ratio	1,52	4,37
inventory turnover, days	240,13	83,52
cycle inventory, pcs	10	17,33
passive inventory, pcs	36	0
standard deviation of demand, pcs	8,18	6,85

2.2 Product4

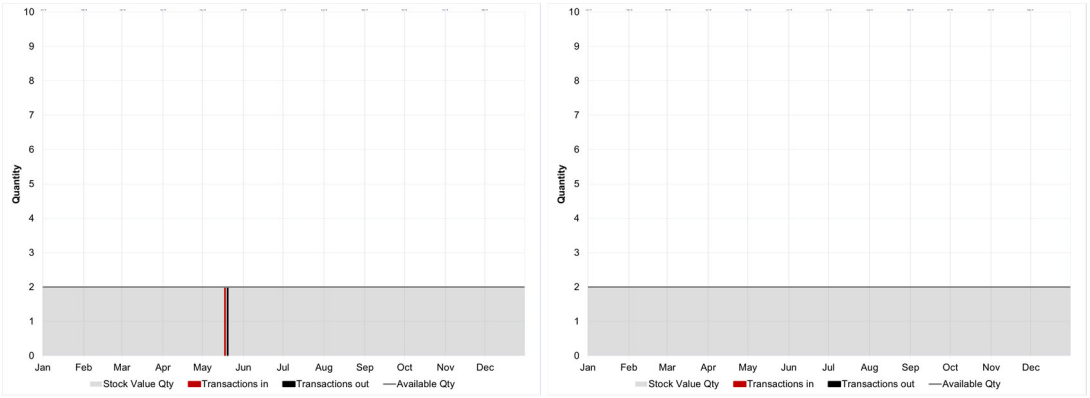

Figure 8. Stock profiles, 2016 and 2017

1. Stock levels in right relation to the demand?
   The stock level was 2 pieces over the years. Demand on 2016 was only two pieces by one transaction out. Since there was transaction in and out at the same time, it seems that the products were purchased despite the fact that there were needed amount in stock and the need could have been met with the existing stock. Two pieces of no profit in stock on 2017. (figure 8)

2. Right amount and timely purchased?
   No demand or need to meet by purchasing over the years. (figure 8)

3. Stock necessity?
   Yes.

Basic data of Product4 is summarized in table 14.

Table 14. Basic data of Product4

	2016	2017
annual demand, pcs	2	0
average of yearly stock, pcs	2	2
highest yearly stock, pcs	2	2
lowest yearly stock, pcs	2	2
SKU inventory value, euros		
inventory turnover ratio	1	1
inventory turnover, days	365	365
cycle inventory, pcs	1	0
passive inventory, pcs	1	2
standard deviation of demand, pcs	0.58	0

2.3 Product5

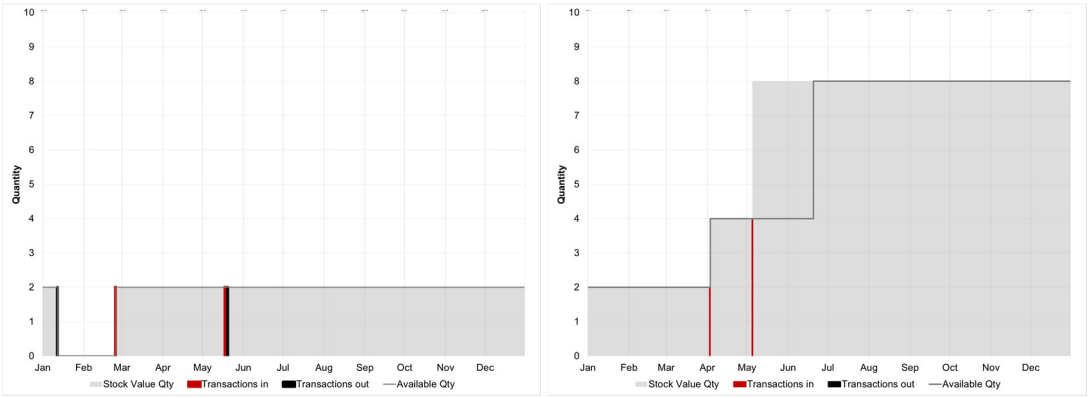

Figure 9. Stock profiles, product5; 2016 and 2017

1. Stock levels in right relation to the demand?
   Beginning stock was two pieces in 2016. Total demand was four pieces. Ending stock was two pieces. Stock level in 2016 was in right relation to the demand. On 2017 no demand existed. Beginning stock was two pieces and ending stock was eight pieces. Overstock existed over the 2017. (figure 9)

2. Right amount and timely purchased?
   Six pieces of no profit purchased on 2017. (figure 9).

3. Stock necessity?
   Yes.

Basic data of Product5 summarized in table 15.

Table 15. Basic data of Product5

	2016	2017
annual demand, pcs	4	0
average of yearly stock, pcs	1,83	6,25
highest yearly stock, pcs	2	8
lowest yearly stock, pcs	0	2
SKU inventory value, euros		
inventory turnover ratio	2,19	0
inventory turnover, days	166,67	365
cycle inventory, pcs	1	1,5
passive inventory, pcs	1	6,5
standard deviation of demand, pcs	0,78	-

2.4 Product6

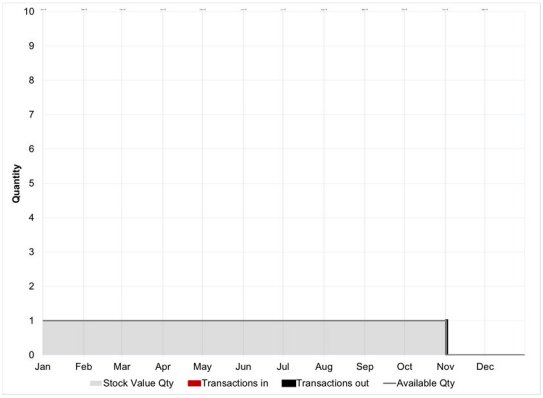

Figure 10. Stock profile, product6; 2016

1. Stock levels in right relation to the demand?
   Beginning stock was one piece in 2016. Only one transaction out on November 2016, no stock held afterwards. Stock level was in right relation to the demand. (figure 10)

2. Right amount and timely purchased?
   No purchases during 2016 or 2017. (figure 10)

3. Stock necessity?
   Yes.

Basic data of product6 summarized in table 16.

Table 16. Basic data of Product6

	2016	2017
annual demand, pcs	1	-
average of yearly stock, pcs	0,83	-
highest yearly stock, pcs	1	-
lowest yearly stock, pcs	0	-
SKU inventory value, euros		
inventory turnover ratio	1,20	-
inventory turnover, days	304,17	-
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,29	-

2.5 Product7

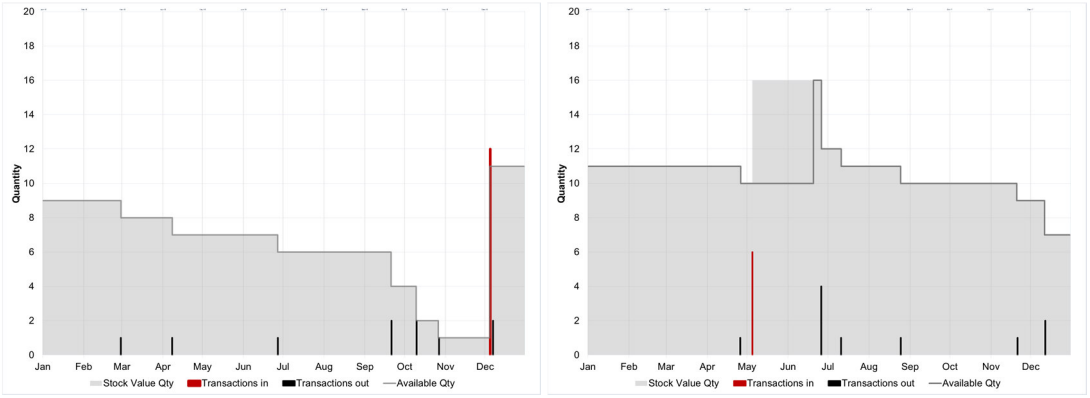

Figure 11. Stock profiles, product7; 2016 and 2017

1. Stock levels in right relation to the demand?

   In 2016, beginning stock was nine pieces, ending stock was eleven pieces and total demand was ten pieces. The demand was intermittent but demand sizes varied only between one and two pieces. Transactions out occurred seven times. In 2017, beginning stock was eleven pieces, ending stock was seven pieces and total demand was ten pieces, same as previous year. The demand was intermittent and demand sizes varied between one and four pieces. Transactions out occurred 6 times. In 2016 and 2017 stock levels, compared to demand, were high. (figure 11)

2. Right amount and timely purchased?
   Released purchases were done at the wrong time, also too many pieces purchased to the stock. (figure 11)

3. Stock necessity?
   Yes. The company wants to keep the product in stock.

   Basic data of product7 summarized in table 17.

Table 17. Basic data of product7

	2016	2017
annual demand, pcs	10	10
average of yearly stock, pcs	6,17	10,67
highest yearly stock, pcs	11	16
lowest yearly stock, pcs	1	7
SKU inventory value, euros		
inventory turnover ratio	1,62	0,98
inventory turnover, days	225,30	372,45
cycle inventory, pcs	6	3
passive inventory, pcs	5	4
standard deviation of demand, pcs	1,03	1,19

2.6 Product8

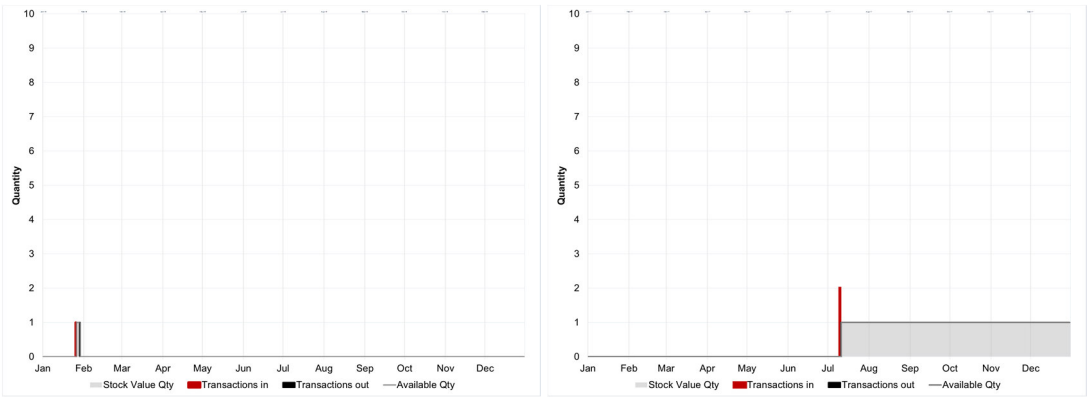

Figure 12. Stock profiles, product8; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016 and 2017, demand was one piece per year. Stock levels were in right relation to the demand. (figure 12)

2. Right amount and timely purchased?
   Right amount purchased but orders were probably placed after the demand has occurred. (figure 12)

3. Stock necessity?
   Yes.

Basic data of product8 summarized in table 18.

Table 18. Basic data of product8

	2016	2017
annual demand, pcs	1	1
average of yearly stock, pcs	0,08	0,5
highest yearly stock, pcs	1	2
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	-	2
inventory turnover, days	-	182,50
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,29	0,29

2.7 Product9

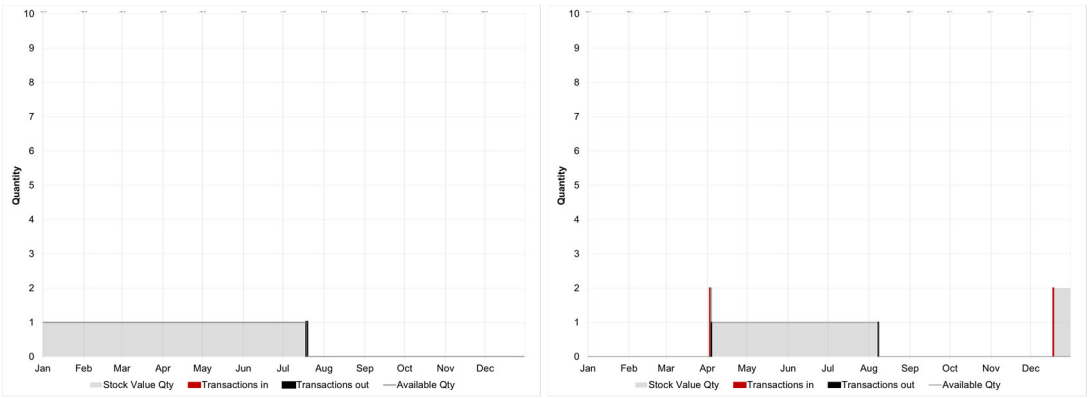

Figure 13. Stock profiles, product9; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, beginning stock was one piece, demand was one piece and it occurred on July, no stock held afterwards. In 2017, total demand was two pieces and

transactions out was made on April and August. Ending stock was two pieces in 2017. Stock levels were in right relation to the demand. (figure 13)

2. Right amount and timely purchased?
   Seems that in 2017 the first order of two pieces was released after the demand occurred. The first order should have been released for example in the beginning of 2017, so that the demand could have been met immediately from stock. Another order of two pieces received on December which indicates that the order has been released on right time to meet demand from stock in 2018. (figure 13)

3. Stock necessity?
   Yes.

Basic data of product9 summarized in table 19.

Table 19. Basic data of product9

	2016	2017
annual demand, pcs	1	2
average of yearly stock, pcs	0,5	0,5
highest yearly stock, pcs	1	2
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	2	4
inventory turnover, days	182,50	91,25
cycle inventory, pcs	0	1
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,29	0,39

2.8 Product10

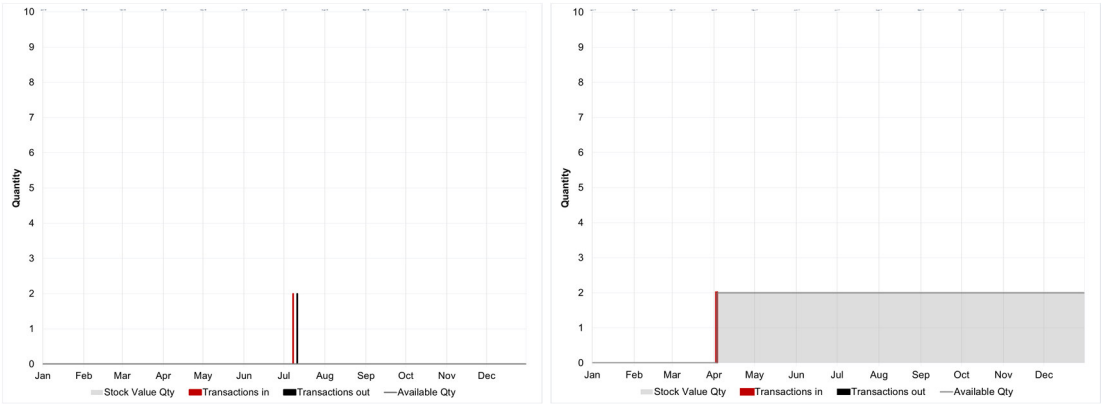

Figure 14. Stock profiles, product10; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, demand was two pieces, no stock held before or after the demand. In 2017, no demand, but stock was held of two pieces starting from April. Ending stock was two pieces. (figure 14)

2. Right amount and timely purchased?
   In 2016, purchase order of two pieces placed after the demand was occurred. Should have been released earlier to meet the demand from stock. On April 2017, two pieces purchased to stock. (figure 14)

3. Stock necessity?
   Yes.

Basic data of product10 summarized in table 20.

Table 20. Basic data of product10

	2016	2017
annual demand, pcs	2	0
average of yearly stock, pcs	0	1,5
highest yearly stock, pcs	2	2
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	-	-
inventory turnover, days	-	-
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,58	-

2.9 Product11

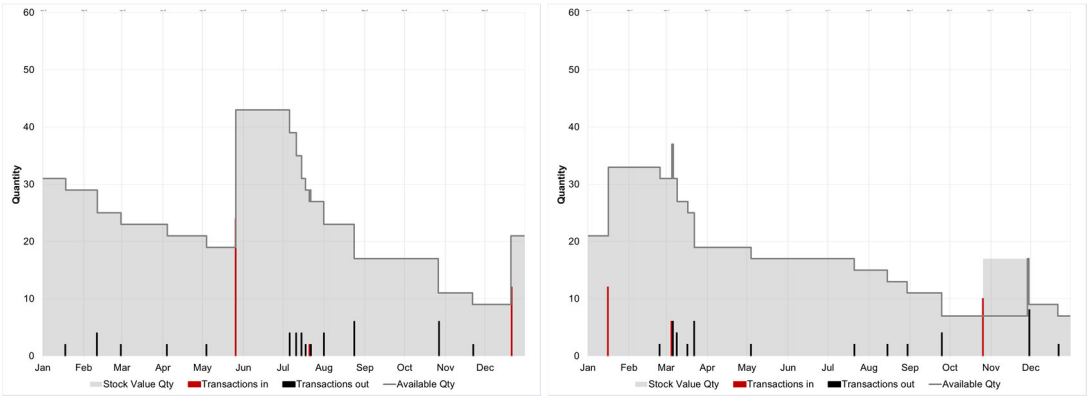

Figure 15. Stock profiles, product11; 2016 and 2017

1. Stock levels in right relation to the demand?

   In 2016, demand was 46 pieces (48 pieces minus a customer return of 2 pieces), transactions out happened 15 times and held each two to six pieces of the product. Beginning stock was 31 pieces, lowest stock level was nine pieces and ending stock was 21 pieces. No demand on every month but still transactions out took place during the year. Held stock ensured immediate response to the demand and no lack of the product occurred. Seems that there were a bit more stock than needed. In 2017, demand was 36 pieces (42 pieces minus a customer return of 6 pieces), transactions out happened 12 times and held each two to eight pieces of the product. Beginning stock was 21 pieces, lowest stock level was seven pieces and ending stock was seven pieces. No demand on every

month but still transactions out took place during the year. Seems that on the last quarter there were a lack of the product because the transaction in and out occurred at the same date on December and before the transaction in the stock level was seven pieces and the amount of the transaction out was eight pieces. (figure 15)

2. Right amount and timely purchased?
   In 2016, transactions in took place three times and they held 24, 2 and 12 pieces of the product. Purchase timings were unplanned and for example by one transaction in holding 20 pieces of the product would have been enough to meet the demand. In 2017, again, transactions in took place three times and they held 12, 6 and 10 pieces of the product. Purchase timings failed again and stock level was too low on the last quarter. (figure 15)

3. Stock necessity?
   Yes.

Basic data of product11 summarized in table 21.

Table 21. Basic data of product11

	2016	2017
annual demand, pcs	46	36
average of yearly stock, pcs	23,67	16,83
highest yearly stock, pcs	43	37
lowest yearly stock, pcs	9	7
SKU inventory value, euros		
inventory turnover ratio	1,94	2,38
inventory turnover, days	188,14	153,36
cycle inventory, pcs	9	5,5
passive inventory, pcs	12	1,5
standard deviation of demand, pcs	4,90	5,13

2.10 Product12

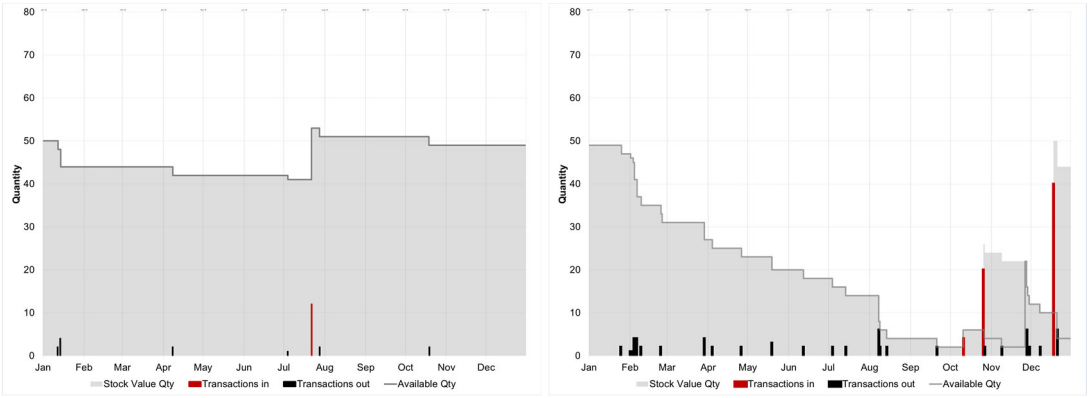

Figure 16. Stock profiles, product12; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, demand was 13 pieces, transactions out happened six times and held each one to four pieces. Beginning stock was 50 pieces, lowest stock level was 41 pieces, highest stock level was 53 pieces and ending stock was 49 pieces. Stock level during the year was very high related to the demand. In 2017, demand was 69 pieces, transactions out happened 26 times and held each one to six pieces. Beginning stock was 49 pieces, lowest stock level was two pieces, highest stock level was 49 pieces and ending stock was four pieces. Stock level varied too much. With demand that smooth, stock level could have beeen kept more stable. Stock levels during the years weren't in a right relation to the demand. Worth noting that the demand is highly variable in annually viewed. (figure 16)

2. Right amount and timely purchased?
   In 2016, purchased once 12 pieces without any reasons. In 2017, purchased twice, 20 pieces and 40 pieces. One transaction in containing four pieces of the product was done on October 2017, to return incorrect project issue back to stock. With demand that smooth, purchases in 2017, could be placed more often and with a smaller amount. Both purchase orders in 2017, were released too late. (figure 16)

3. Stock necessity?
   Yes.

Basic data of product12 summarized in table 22.

Table 22. Basic data of product12

	2016	2017
annual demand, pcs	13	69
average of yearly stock, pcs	46,50	21,33
highest yearly stock, pcs	53	50
lowest yearly stock, pcs	41	2
SKU inventory value, euros		
inventory turnover ratio	0,28	4,04
inventory turnover, days	1303,57	90,35
cycle inventory, pcs	6	15
passive inventory, pcs	43	-
standard deviation of demand, pcs	1,88	4,67

2.11 Product13

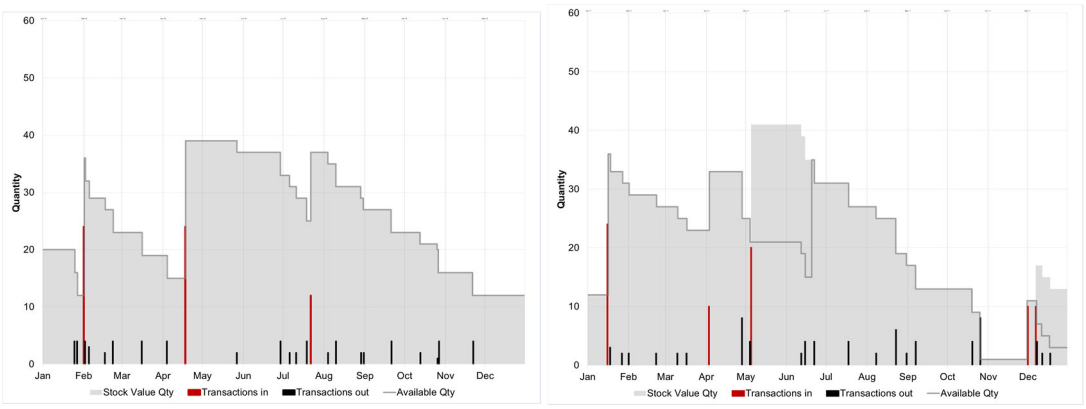

Figure 17. Stock profiles, product13; 2016 and 2017

1. Stock levels in right relation to the demand?

   In 2016, demand was 68 pieces, transaction out happened 23 times and held each one to four pieces. Beginning stock was 20 pieces, lowest stock level was 12 pieces, highest stock level was 39 pieces and ending stock was 12 pieces. Demand occurred on every month except on December. In 2017, demand was 73 pieces, transactions out happened 23 times and held each two to eight pieces. Beginning stock was 12 pieces, lowest stock level was one piece, highest 41 pieces and ending stock was 13 pieces. The demand in 2017 increased by five pieces compared to demand in 2016. On November and December the stock level was too low and lack of the product occurred. Stock levels in both years

varied too much. The demand is quite steady, the stock should have been able to keep on the level to meet the demand without lacks. (figure 17)

2. Right amount and timely purchased?
   Purchase orders were rarely placed and with large order quantities. By cyclic purchasing with smaller order amounts, the stock level, as well as stock values, would have been kept in right relation to the demand during the years, and in 2017, without lack of the product. (figure 17)

3. Stock necessity?
   Yes.

Basic data of product13 summarized in table 23.

Table 23. Basic data of product13.

	2016	2017
annual demand, pcs	68	73
average of yearly stock, pcs	26,17	21,67
highest yearly stock, pcs	39	41
lowest yearly stock, pcs	12	1
SKU inventory value, euros		
inventory turnover ratio	2,60	3,37
inventory turnover, days	140,38	108,31
cycle inventory, pcs	10	12,33
passive inventory, pcs	2	0,67
standard deviation of demand, pcs	3,63	3,48

2.12 Product15

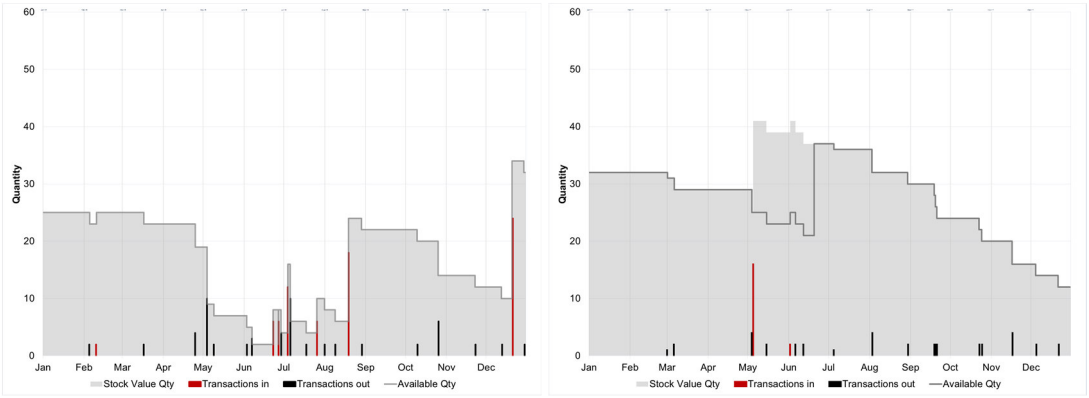

Figure 18. Stock profiles, product15; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, demand was 67 pieces, transactions out happened 20 times and held each two to ten pieces. Beginning stock was 25 pieces, lowest stock level was two pieces, highest stock level was 34 pieces and ending stock was 32 pieces. During the year stock level was high compared to the demand. Except the level was too low from May to September, when most of the demand occurred. In 2017, demand was 38 pieces (29 pieces less that in 2016), transactions out happened 17 times (only three times less than 2016) and held each one to four pieces. Beginning stock was 32 pieces, lowest stock was 12 pieces, highest stock was 41 pieces and ending stock was 12 pieces. Stock level was high compared to the demand over the year. There weren't demand on every month but it occurred during the years. (figure 18)

2. Right amount and timely purchased?
   In 2016, three purchase orders placed with 24 pieces per order. By cyclic ordering in 2016, the stock level as well as stock value, would have been kept steadier. In 2017, one purchase order placed with 16 pieces. Timing was failed, should have been done later. (figure 18)

3. Stock necessity?
   Yes.

Basic data of product15 summarized in table 24.

Table 24. Basic data of Product15

	2016	2017
annual demand, pcs	67	38
average of yearly stock, pcs	17,92	28,17
highest yearly stock, pcs	32	41
lowest yearly stock, pcs	2	12
SKU inventory value, euros		
inventory turnover ratio	3,74	1,35
inventory turnover, days	97,59	270,37
cycle inventory, pcs	12	8
passive inventory, pcs	0	4
standard deviation of demand, pcs	5,07	2,37

2.13 Product17

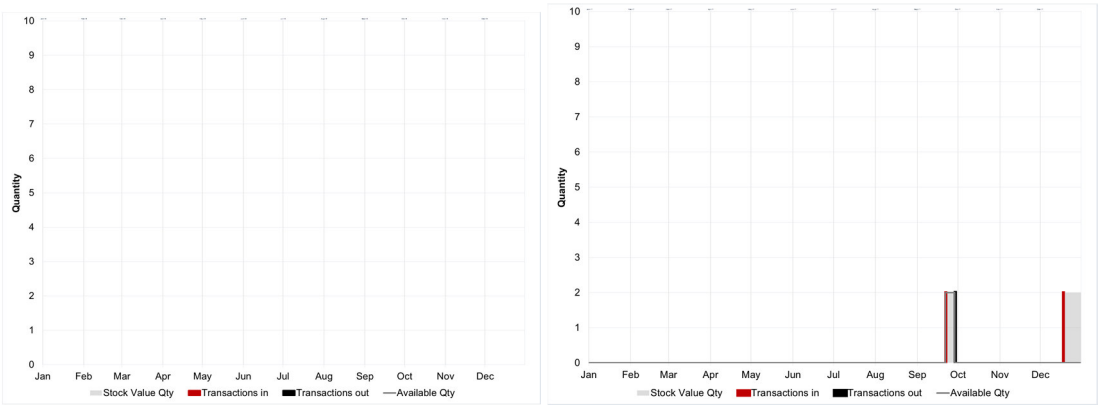

Figure 19. Stock profile, product17; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, no demand or stock held. In 2017, demand was 2 pieces by 1 transaction out. Stock levels were on right relation to the demand. (figure 19)

2. Right amount and timely purchased?
   In 2016, no purchases done. In 2017, purchased 2 times and first purchase released after the demand has occurred. Purchase orders held 2 pieces of the product per order. (figure 19)

3. Stock necessity?
   Yes.

Basic data of product17 summarized in table 25.

Table 25. Basic data of Product17

	2016	2017
annual demand, pcs	-	2
average of yearly stock, pcs	-	0,17
highest yearly stock, pcs	-	2
lowest yearly stock, pcs	-	0
SKU inventory value, euros		
inventory turnover ratio	-	-
inventory turnover, days	-	-
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	-	0,58

2.14 Product18

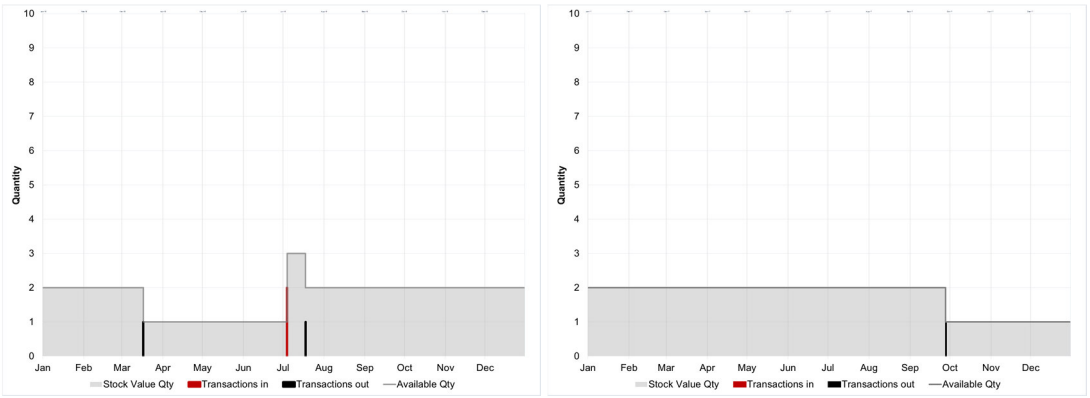

Figure 20. Stock profiles, product 18; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was 2 pieces, transaction out happened 2 times; on March and on July. Beginning stock was 2 pieces, lowest stock level was 1 pieces, highest stock level was 3 pieces and ending stock was 2 pieces. In 2017, demand was 1 piece and ending stock was 1 piece as well. Stock levels in both years were in right relation to the demand. (figure 20)

2. Right amount and timely purchased?
   Two pieces purchased in 2016. No purchases on 2017. Seems that placing an order for two pieces when stock level reach the zero, is enough to meet the demand in a year. (figure 20)

3. Stock necessity?
   Yes.

Basic data of product18 summarized in table 26.

Table 26. Basic data of product18

	2016	2017
annual demand, pcs	2	1
average of yearly stock, pcs	1,67	1,67
highest yearly stock, pcs	3	2
lowest yearly stock, pcs	1	1
SKU inventory value, euros		
inventory turnover ratio	-	-
inventory turnover, days	-	-
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,39	0,29

2.15 Product19

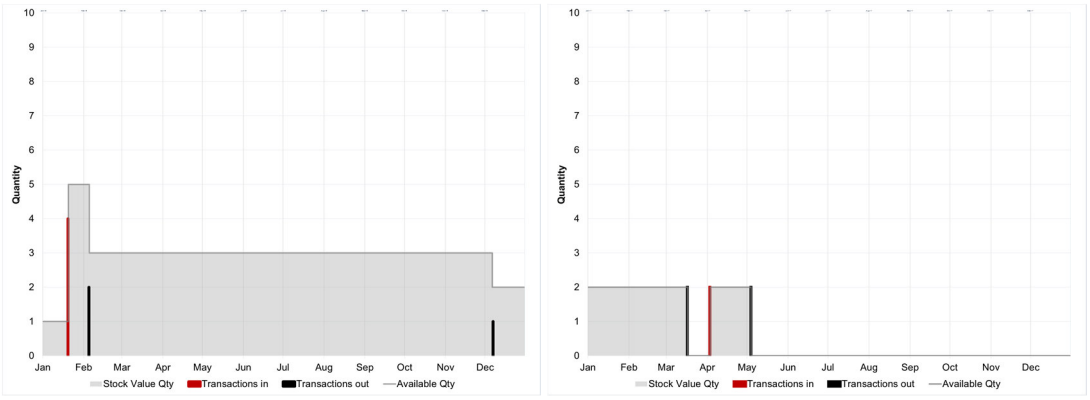

Figure 21. Stock profiles, product19; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was three pieces, transaction out happened two times and held one and two pieces of the product. Beginning stock was one piece, lowest stock level was one piece, highest stock level was five pieces and ending stock was two pieces. In 2017, total demand was four pieces and transaction out happened two times and they held each two pieces. Beginning stock was two pieces, lowest stock level was zero, highest stock level was two pieces and ending stock was zero. Stock levels were in right relation to the demand. (figure 21)

2. Right amount and timely purchased?
   Only one purchase order done per year which is reasonable way to handle purchasing the product demand this low. (figure 21)

3. Stock necessity?
   Yes.

Basic data of product19 summarized in table 27.

Table 27. Basic data of Product19

	2016	2017
annual demand, pcs	3	4
average of yearly stock, pcs	3,08	0,58
highest yearly stock, pcs	5	2
lowest yearly stock, pcs	1	0
SKU inventory value, euros		
inventory turnover ratio	0,97	8
inventory turnover, days	376,29	45,63
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,62	0,78

2.16 Product20

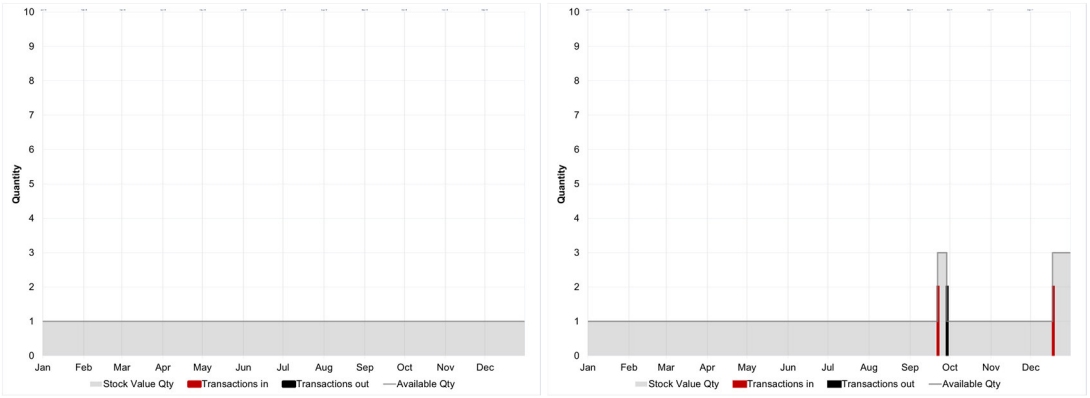

Figure 22. Stock profiles, product20; 2016 and 2017

1. Stock levels in right relation to the demand?
   No demand in 2016 and only 1 piece kept in stock over the year. In 2017, total demand was 2 pieces by 1 transaction out. Beginning stock was 1 piece and ending stock was 3 pieces. Stock levels were low enough compared to the demands. (figure 22)

2. Right amount and timely purchased?
   Seems that in 2017 the order has been released after the demand has occurred and with the demanded quantity even though the stock held one piece. One order of two pieces would have covered the year's demand. (figure 22)

3. Stock necessity?
   Yes.

Basic data of product20 summarized in table 28.

Table 28. Basic data of Product20

	2016	2017
annual demand, pcs	0	2
average of yearly stock, pcs	1	1,17
highest yearly stock, pcs	1	3
lowest yearly stock, pcs	1	1
SKU inventory value, euros		
inventory turnover ratio	-	1,71
inventory turnover, days	-	213,45
cycle inventory, pcs	-	1
passive inventory, pcs	-	2
standard deviation of demand, pcs	-	0,58

2.17 Product21

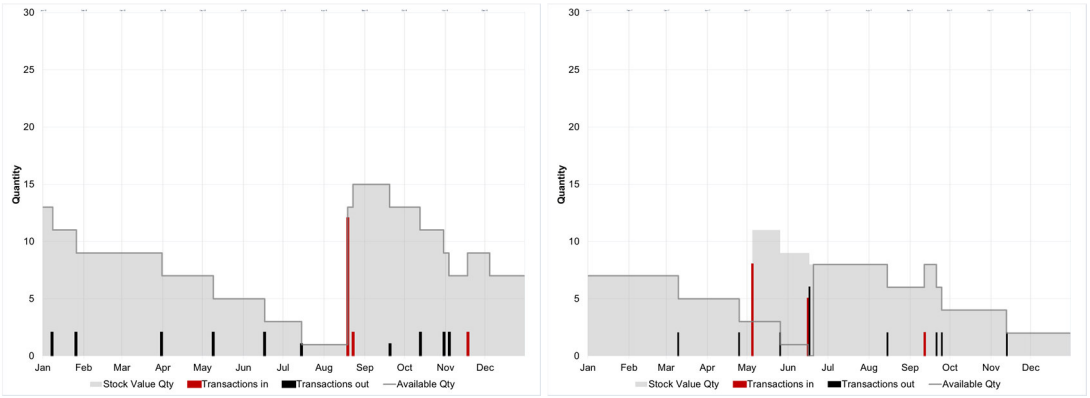

Figure 23. Stock profiles, product21; 2016 and 2017

1. Stock levels in right relation to the demand?

   In 2016, total demand was 22 pieces, transaction out happened 13 times and held each one to two pieces of the product. Beginning stock was 13 pieces, lowest stock level was one pieces, highest stock level was 15 pieces and ending stock was seven pieces. The demand was fairly steady during the year. In 2017, total demand was 20 pieces, transaction out happened ten times and held each one to three pieces of the product. Beginning stock was seven pieces, lowest stock level was zero, highest stock level was 11 pieces and ending stock was two pieces. The demand was more intermittent and erratic than in 2016. The levels varied too much during the years, and should have been kept steadier. This could have been quite easy to execute in 2016, but in 2017 the demand that lumpy, it would have been challenging. (figure 23)

2. Right amount and timely purchased?
   In 2016, one purchase order done which was received on August. The order held 12 pieces. Acquisition could have been done in two batches to keep the stock value steadier. In 2017, lack of the product occurred. (figure 23)

3. Stock necessity?
   Yes.

Basic data of product21 summarized in table 29.

Table 29. Basic data of Product21

	2016	2017
annual demand, pcs	22	20
average of yearly stock, pcs	6,83	5,42
highest yearly stock, pcs	15	11
lowest yearly stock, pcs	1	0
SKU inventory value, euros		
inventory turnover ratio	3,22	3,69
inventory turnover, days	113,35	98,92
cycle inventory, pcs	3,5	2,5
passive inventory, pcs	3,5	-
standard deviation of demand, pcs	1,34	1,87

2.18 Product22

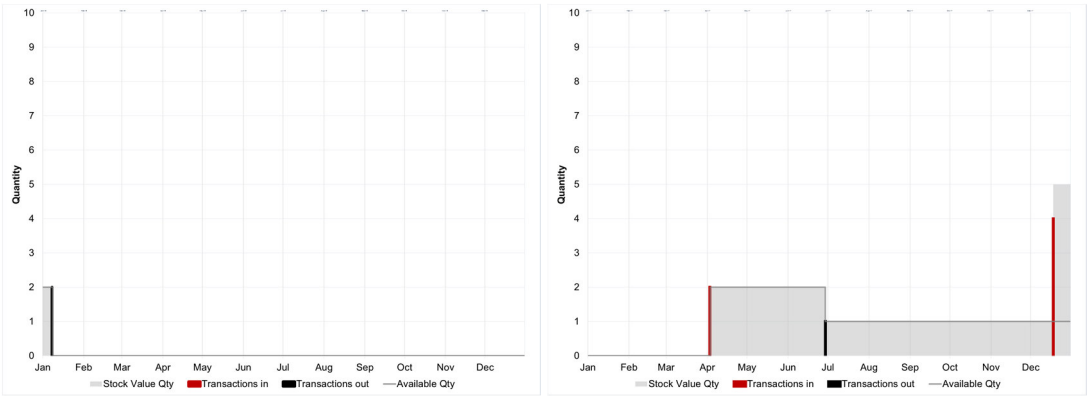

Figure 24. Stock profiles, product22; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was two pieces which was covered on January from beginning stock of two pieces. After the single transaction out, no transactions happened. In 2017, total demand was one piece which was covered from the stock. Beginning stock was zero and ending stock was five pieces. Otherwise the stock levels was in right relation to the demand, except in the end of 2017, when ending stock was five pieces which is high level compared to the demand. (figure 24)

2. Right amount and timely purchased?
   In 2017, two purchases done over the year. The second order of five pieces was unnecessary. (figure 24)

3. Stock necessity?
   Yes.

Basic data of product22 summarized in table 30.

Table 30. Basic data of product22

	2016	2017
annual demand, pcs	2	1
average of yearly stock, pcs	-	1,25
highest yearly stock, pcs	-	5
lowest yearly stock, pcs	-	1
SKU inventory value, euros		
inventory turnover ratio	-	0,8
inventory turnover, days	-	456,25
cycle inventory, pcs	-	1,5
passive inventory, pcs	-	3,5
standard deviation of demand, pcs	0,58	0,29

2.19 Product23

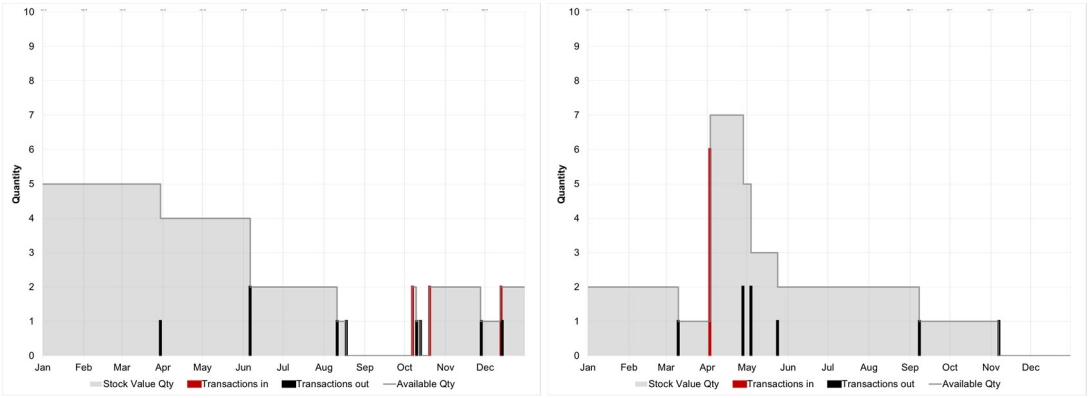

Figure 25. Stock profiles, product23; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was nine pieces, transaction out happened eight times and held each one piece except one held two pieces. Beginning stock was five pieces, lowest stock level was zero, highest stock level was five pieces and ending stock was two pieces of the product. Stock level was too low compared to the demand. In 2017, total demand was eight pieces, transaction out happened six times and held each one to two pieces. Beginning stock was two pieces, lowest stock level was zero, highest stock level was seven pieces and ending stock was zero. Stock level was too low compared to the demand. (figure 25)

2. Right amount and timely purchased?
   In 2016, there were lack of the product. Three purchases of which held each two pieces, were done over the year. One of them was made too late, goods received on October. In 2017, one purchase order released which was enough to meet the demand. (figure 25)

3. Stock necessity?
   Yes.

Basic data of Product23 summarized in table 31.

Table 31. Basic data of Product23.

	2016	2017
annual demand, pcs	9	8
average of yearly stock, pcs	2,58	1,67
highest yearly stock, pcs	5	7
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	3,49	4,79
inventory turnover, days	104,58	76,20
cycle inventory, pcs	1	3
passive inventory, pcs	1	-
standard deviation of demand, pcs	0,87	0,98

2.20 Product24

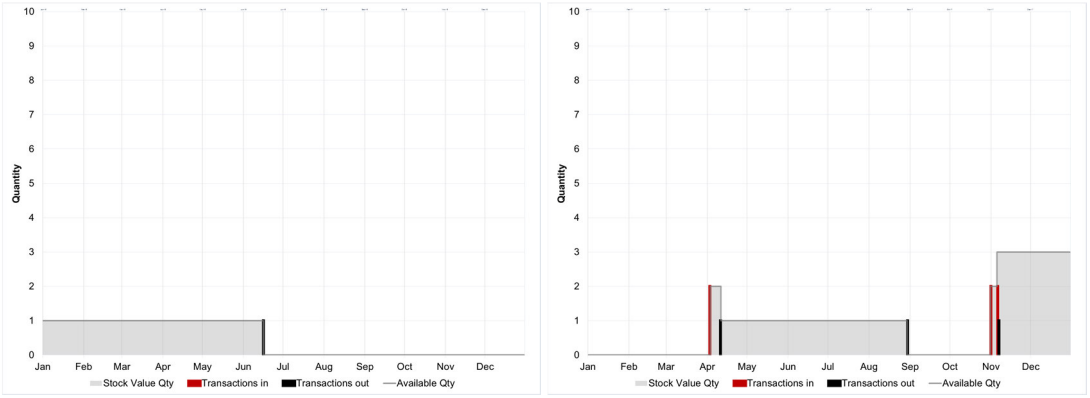

Figure 26. Stock profiles, product24; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was one piece which was met from stock. After the single transaction out on June, no stock held. In 2017, total demand was four pieces by four transactions out. Stock level was low compared to the demand. (figure 26)

2. Right amount and timely purchased?
   No purchases in 2016. In 2017, two pieces purchased in the beginning of the year to meet the demand over the year. There was lack of the product, because total demand was more than expected. Four pieces purchased after the demand occurred. (figure 26)

3. Stock necessity?
   Yes.

Basic data of product24 summarized in table 32.

Table 32. Basic data of product24

	2016	2017
annual demand, pcs	1	4
average of yearly stock, pcs	0,42	0,83
highest yearly stock, pcs	1	3
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	2,38	3,61
inventory turnover, days	153,36	101,11
cycle inventory, pcs	-	1
passive inventory, pcs	-	2
standard deviation of demand, pcs	0,29	0,65

2.21 Product26

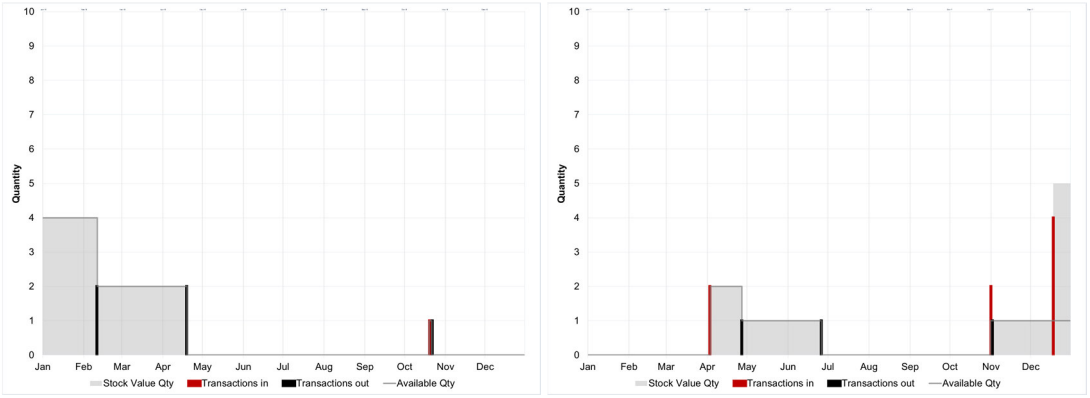

Figure 27. Stock profiles, product26; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was five pieces, transaction out happened three times and held two, two and one pieces. Beginning stock as well as the highest stock level was four pieces and lowest stock level as well as ending stock was zero. Lack occurred, stock level was too low. In 2017, total demand was three pieces by three transactions out. Beginning stock as well as lowest stock level were zero and highest stock level was five pieces. Lack of the product occurred, stock level was too low. (figure 27)

2. Right amount and timely purchased?
   Lack of the product occurred over the years, timing of the purchases were failed. With demand this predictable, purchases could have been possible to be handled without lacks in stock. (figure 27)

3. Stock necessity?
   Yes.

Basic data of product26 summarized in table 33.

Table 33. Basic data of product26

	2016	2017
annual demand, pcs	5	3
average of yearly stock, pcs	0,67	0,67
highest yearly stock, pcs	4	5
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	7,46	4,48
inventory turnover, days	48,93	81,47
cycle inventory, pcs	0,5	1,33
passive inventory, pcs	-	3,67
standard deviation of demand, pcs	0,79	0,45

2.22 Product28

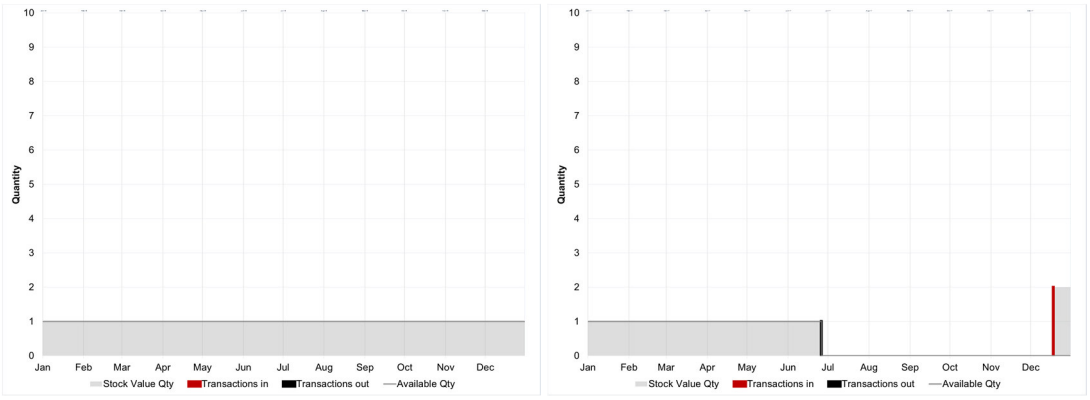

Figure 28. Stock profiles, product28; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, no demand occurred and stock level remained in one piece over the year. In 2017, total demand was one piece by one transaction out. Beginning stock was one piece and ending stock was two pieces. Compared to the demand in both years, the stock levels were in right relation to the demands. (figure 28)

2. Right amount and timely purchased?
   Only two pieces purchased on December 2017. The product was timely purchased with a right order amount. (figure 28)

3. Stock necessity?
   Yes.

Basic data of product28 summarized in table 34.

Table 34. Basic data of product28

	2016	2017
annual demand, pcs	-	1
average of yearly stock, pcs	1	0,58
highest yearly stock, pcs	1	2
lowest yearly stock, pcs	1	0
SKU inventory value, euros		
inventory turnover ratio	-	1,72
inventory turnover, days	-	212,21
cycle inventory, pcs	-	1
passive inventory, pcs	-	1
standard deviation of demand, pcs	-	0,29

2.23 Product29

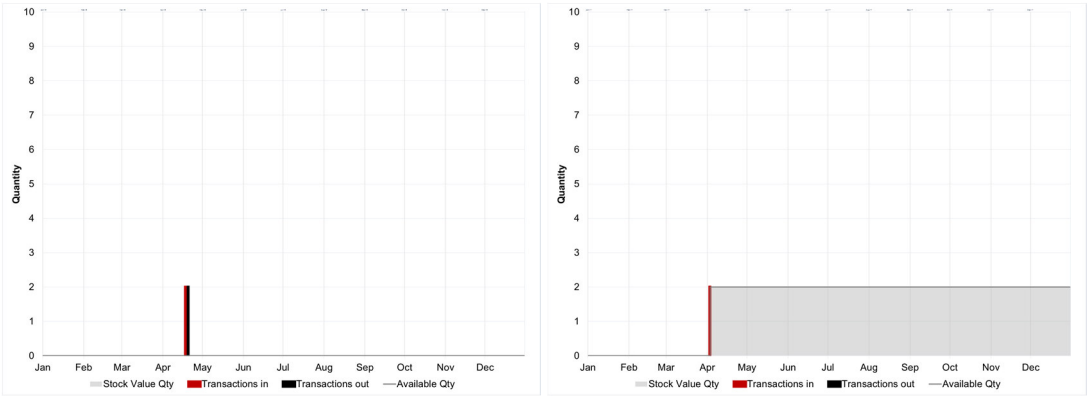

Figure 29. Stock profiles, product29; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was two pieces by one transaction out. No stock held over the year. In 2017, no demand over the year and two pieces kept in stock starting from April. Stock levels were in right relation to the demands. (figure 29)

2. Right amount and timely purchased?
   There was lack of the product in 2016, purchase order with demanded quantity released after the demand occurred. The order could have been released so that the amount would have been in stock in the beginning of the year to meet the future demand. In 2017, two pieces received into stock on April. (figure 29)

3. Stock necessity?
   Yes.

Basic data of product29 summarized in table 35.

Table 35. Basic data of Product29

	2016	2017
annual demand, pcs	2	0
average of yearly stock, pcs	0	1,5
highest yearly stock, pcs	2	2
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	-	-
inventory turnover, days	-	-
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,58	-

2.24 Product30

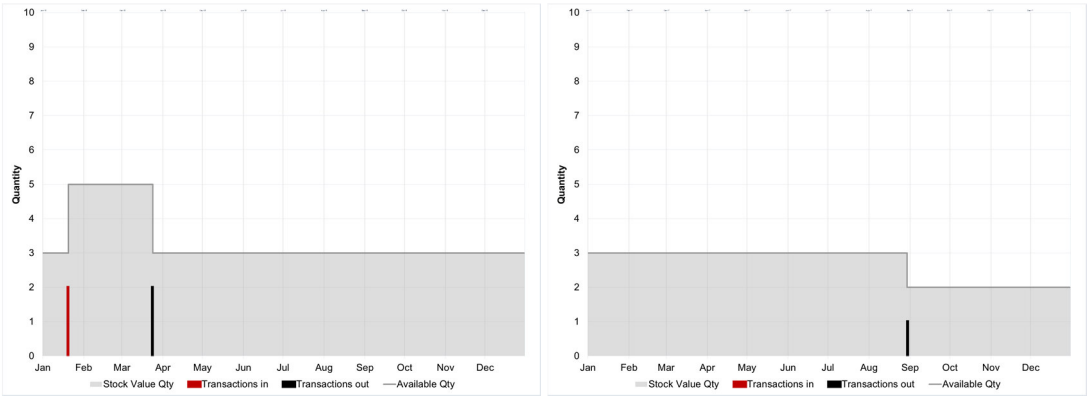

Figure 30. Stock profiles, product30; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was two pieces by one transaction out. Beginning stock as well as the lowest stock level and ending stock was three pieces. Highest stock level was five pieces. In 2017, total demand was one piece by one transaction out and ending stock was two pieces. Compared to the demands stock levels were high over the years. (figure 30)

2. Right amount and timely purchased?
   Ordered once in 2016 without any reason. Order amount of two pieces was right amount compared to the demand but timing failed. There were no need to order in 2016. (figure 30)

3. Stock necessity?

   Yes.

Basic data of product30 summarized in table 36.

Table 30. Basic data of product36

	2016	2017
annual demand, pcs	2	1
average of yearly stock, pcs	3,33	2,58
highest yearly stock, pcs	5	3
lowest yearly stock, pcs	3	2
SKU inventory value, euros		
inventory turnover ratio	0,60	0,39
inventory turnover, days	608,33	935,90
cycle inventory, pcs	1	-
passive inventory, pcs	2	-
standard deviation of demand, pcs	0,58	0,29

2.25 Product31

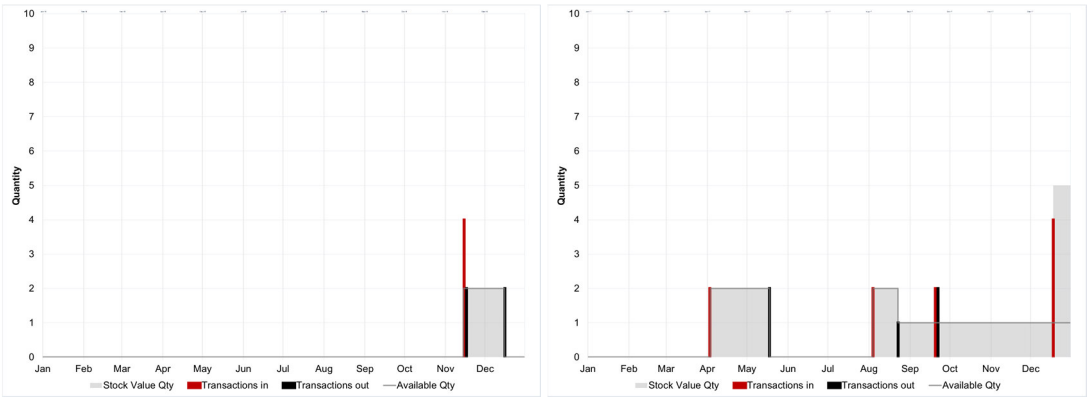

Figure 31. Stock profiles, product31; 2016 and 2017

1. Stock levels in right relation to the demand?

   In 2016, total demand was four pieces by two transactions out holding each two pieces of the product. Beginning and ending stock was zero and highest stock level was four pieces. In 2017, total demand was five pieces by three transactions out holding two, one and two pieces. Compared to the demands stock levels in the beginning of the years were too low. (figure 31)

2. Right amount and timely purchased?
   In 2016, purchase were released after the demand occurred and it should have been done in the end of 2015 or in the beginning of 2016. In 2017, four purchase orders released at random time. The needed amount could have been purchased at one time in the beginning of the year. (figure 31)

3. Stock necessity?
   Yes.

Basic data of product31 summarized in table 37.

Table 37. Basic data of product31

	2016	2017
annual demand, pcs	4	5
average of yearly stock, pcs	0,17	0,92
highest yearly stock, pcs	4	5
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	23,53	5,43
inventory turnover, days	15,51	67,22
cycle inventory, pcs	2	1,25
passive inventory, pcs	-	3,75
standard deviation of demand, pcs	0,78	0,79

2.26 Product32

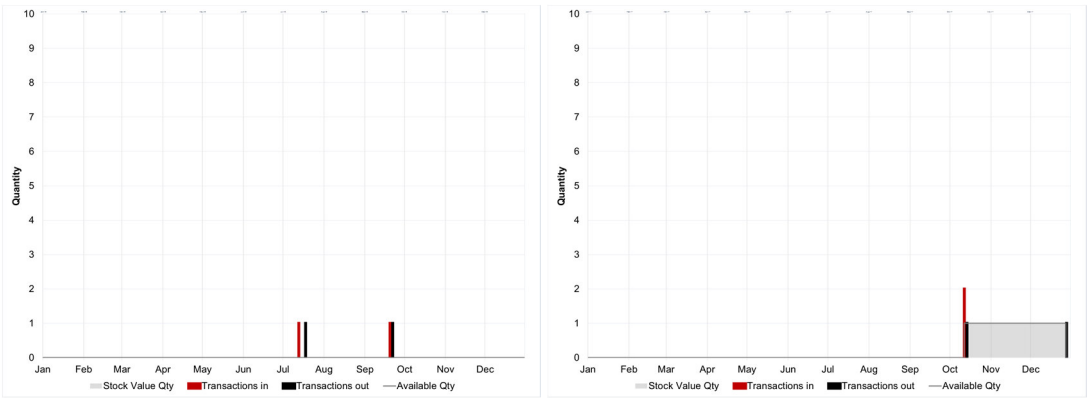

Figure 32. Stock profiles, product32; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016 and in 2017, total demand was two pieces per year. In 2016, no stock held. In 2017, stock of one piece which remained in stock less than three months before demand occurred. Stock levels were in good relation compared to the demands. (figure 32)

2. Right amount and timely purchased?
   There were lack of the product in 2016 and 2017, because the purchase orders were released after the demands occurred. There orders should have been released in the beginning of the years to meet the future demand. (figure 32)

3. Stock necessity?
   Yes.

Basic data of product32 summarized in table 38.

Table 38. Basic data of product32

	2016	2017
annual demand, pcs	2	2
average of yearly stock, pcs	0	0,17
highest yearly stock, pcs	1	2
lowest yearly stock, pcs	0	0
SKU inventory value, euros		
inventory turnover ratio	-	11,76
inventory turnover, days	-	31,04
cycle inventory, pcs	-	-
passive inventory, pcs	-	-
standard deviation of demand, pcs	0,39	0,39

2.27 Product34

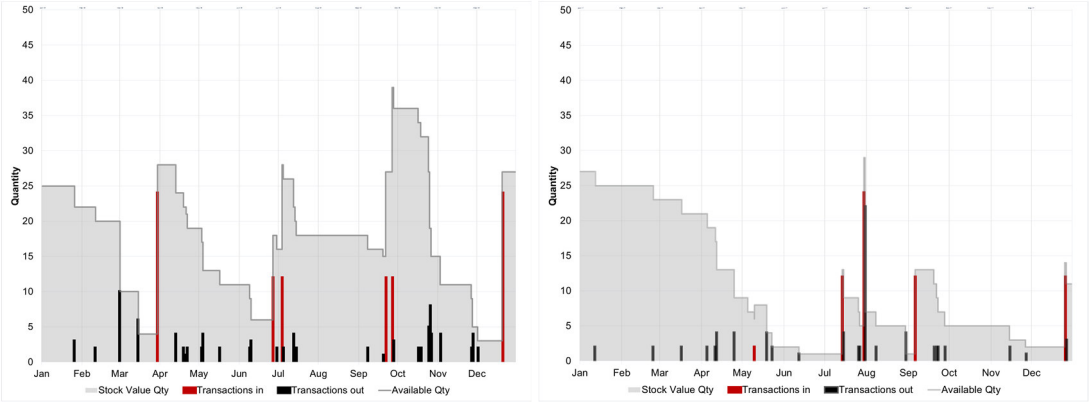

Figure 33. Stock profiles, product34; 2016 and 2017

1. Stock levels in right relation to the demand?
   In 2016, total demand was 98 pieces, transaction out happened 30 times and held each one to ten pieces of the product. Beginning stock was 25 pieces, lowest stock level was three pieces, highest stock level was 39 pieces and ending stock was 27 pieces. In 2017, total demand was 78 pieces, transaction out happened 31 times and held each one to eight pieces of the product. Beginning stock was 27 pieces, lowest stock level was one piece, highest stock level was 29 pieces and ending stock was 11. In 2016, stock level was variable but in right relation to the demand. In 2017, stock level varied a lot and was too low, also a lack occurred. (figure 33)

2. Right amount and timely purchased?
   In 2016 and 2017, lack of the product existed. The timings of purchases were failed, while ordered amounts were sufficient to be met the need. (figure 33)

3. Stock necessity?
   Yes.

Basic data of product34 summarized in table 39.

Table 39. Basic data of product34

	2016	2017
annual demand, pcs	94	78
average of yearly stock, pcs	19,58	9,33
highest yearly stock, pcs	39	29
lowest yearly stock, pcs	3	1
SKU inventory value, euros		
inventory turnover ratio	4,80	8,36
inventory turnover, days	76,04	43,66
cycle inventory, pcs	12	7,5
passive inventory, pcs	15	3,5
standard deviation of demand, pcs	6,09	8,25

3. Safety Stocks, Order points and amounts

The calculations in this appendix were done to illustrate the effects of different service levels. Please note, the values used in the illustration are not actual values due to company confidentiality reasons, calculations below were done only for illustrative purposes.

The following equations were used for calculations (chapter 5.3):

$$Safety\ stock = Z\sqrt{\frac{PC}{T_1}}\sigma_D$$

Z standard score
PC performance cycle (lead time)
T_1 time increment used for calculating standard deviation of demand
σ_D standard deviation of demand

Order point lead time average demand + safety stock
Order Qty lead time average demand

The calculations were performed for three different service levels: 95%, 90%. and 99%.

service level 95 %
standard score (Z) 1.65

Poduct	σ_D	*PC average demand*	*Safety stock*	*Order point*	*Order Qty*	*Purchase price, €*	*Safety stock value, €*
1	5.85	44	17	61	44	131.25	2278.03
2	4.13	10	12	22	10	308.75	3783.22
3	3.67	21	11	32	21	346.25	3770.16
4	2.48	25	7	32	25	382.5	2814.41
5	3.37	10	10	20	10	755	7548.85
6	2.87	4	9	13	4	1103.75	9398.46
7	1.98	2	6	8	2	666.25	3913.87
8	0.25	22	1	23	22	261.25	193.78
total			**73**		**138**		**33700.77**

service level 90 %
standard score (Z) 1.25

Poduct	σ_D	*PC average demand*	*Safety stock*	*Order point*	*Order Qty*	*2018 Purchase price, €*	*Safety stock inventory value, €*
1	5.85	44	13	57	44	131.25	1725.78
2	4.13	10	9	19	10	308.75	2866.07
3	3.67	21	8	29	21	346.25	2856.18
4	2.48	25	6	31	25	382.5	2132.13
5	3.37	10	8	18	10	755	5718.83
6	2.87	4	6	10	4	1103.75	7120.04
7	1.98	2	4	6	2	666.25	2965.05
8	0.25	22	1	23	22	261.25	146.80
total			**55**		**138**		**25530.89**

service level 99 %
standard score (Z) 2.33

Poduct	σ_D	*PC average demand*	*Safety stock*	*Order point*	*Order Qty*	*2018 Purchase price, €*	*Safety stock inventory value, €*
1	5.85	44	25	69	44	131.25	3216.85
2	4.13	10.00	17	27	10	308.75	5342.36
3	3.67	21.00	15	36	21	346.25	5323.92
4	2.48	25.00	10	35	25	382.5	3974.29
5	3.37	10.00	14	24	10	755	10659.89
6	2.87	4.00	12	16	4	1103.75	13271.76
7	1.98	2.00	8	10	2	666.25	5526.86
8	0.25	22	1	23	22	261.25	273.64
total			**103**		**138**		**47589.57**